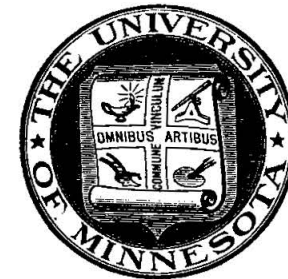


site for the farmstead was located on the east side of the farm. Land has been broken for a windbreak and shelter belt and the fields have been permanently laid out for a 5-year major rotation of grain, hay, hay, corn, and corn. A permanent pasture is provided on some of the wetter land. No attempt has been made to do any special experimental work on the demonstration unit, the effort being to bring that part of the farm under cultivation, to get it properly equipped and stocked, and to operate it as a model farm. It will serve a valuable experimental purpose in that it will provide a means of securing accurate farm-management data. Some experiments in steer- and hog-feeding were carried on but there was not enough difference in the gains made to draw conclusions, and it is intended to repeat the experiment the coming winter.

# The University of Minnesota

## TWENTY-SECOND ANNUAL REPORT OF THE AGRICULTURAL EXPERIMENT STATION

JULY 1, 1913  
TO JUNE 30, 1914



## THE UNIVERSITY OF MINNESOTA

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CHARLES HARALSON, Superintendent, Fruit-Breeding Farm, Excelsior  
J. O. RANKIN, M.A., Editor  
HARRIET W. SEWALL, B.A., Librarian  
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R. M. WEST, B.A., Assistant Agricultural Chemist  
J. J. WILLAMAN, M.A., Assistant Agricultural Chemist  
CORNELIA KENNEDY, B.A., Assistant Agricultural Chemist

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### DIVISION OF AGRONOMY AND FARM MANAGEMENT

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\*C. P. BULL, B.Agr., Associate Agronomist  
T. B. HUTCHESON, M.S., Associate Agronomist  
A. C. ARNY, B.S. in Agr., Assistant Agronomist  
P. J. OLSON, M.S., Assistant Agronomist  
†ALEX CARLYLE, Assistant in Seed Distribution  
L. B. BASSETT, Assistant Farm Management Investigator  
A. H. BENTON, M.S., Assistant Farm Management Investigator  
F. W. PECK, B.S. in Agr., Assistant Farm Management Investigator

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FRANCIS JAGER, Apiculturist

### DIVISION OF DAIRY AND ANIMAL HUSBANDRY

T. L. HAECKER, Dairy and Animal Husbandman

#### *Section of Animal Husbandry*

H. R. SMITH, B.S., Animal Husbandman, in Charge  
J. S. MONTGOMERY, B.S. in Agr., Assistant Animal Husbandman  
T. G. PATERSON, B.S. in Agr., Assistant Animal Husbandman  
†W. F. HAGERMAN, B.S.A., Assistant Animal Husbandman  
‡R. C. ASHBY, B.S., Assistant in Animal Husbandry

\* Absent on leave, 1913-1914.

† Resigned during the year.

‡ Elected to assume duties during the year.

K. F. WARNER, B.A., Assistant in Animal Husbandry

*Section of Dairy Husbandry*

R. M. WASHBURN, M.S.A., Associate Dairy Husbandman

E. O. HANSON, Assistant in Dairy Husbandry

*Section of Poultry Husbandry*

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

C. H. MATTHEWS, Assistant in Poultry Husbandry

*Section of Animal Nutrition*

T. L. HAECKER, Dairy and Animal Husbandman, in Charge

E. W. MAJOR, B.Agr., Associate in Animal Nutrition

STEPHEN ANTHONY, Chemist in Animal Nutrition

MILDRETH HAGGARD, B.A., Chemist in Animal Nutrition

AGNES ERICSON, Assistant Chemist in Animal Nutrition

W. F. CANTWELL, B.S. in Chem., Assistant Chemist in Animal Nutrition

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*Section of Tree Insects and Spraying*

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*Section of Field-Crop Pests and Parasites*

C. W. HOWARD, M.S., Assistant Entomologist, in Charge

WARREN WILLIAMSON, M.A., Assistant in Entomology

*Section of Truck-Crop and Greenhouse Pests*

WILLIAM MOORE, B.A., Assistant Entomologist, in Charge

O. G. BABCOCK, B.S., Assistant Entomologist

DIVISION OF HORTICULTURE

*Section of Floriculture and Landscape Gardening*

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

*Section of Fruit-Breeding*

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

*Section of Fruit and Vegetable Investigation*

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

*Section of Fruit and Vegetable Instruction*

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

DIVISION OF PLANT PATHOLOGY AND BOTANY

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*Section of Plant Pathology*

E. C. STAKMAN, Ph.D., Assistant Plant Pathologist, in Charge

E. LOUISE JENSEN, M.A., Mycologist

A. G. TOLAAS, M.S., Assistant in Plant Pathology

*Section of Seed Laboratory*

W. L. OSWALD, Assistant Botanist, in Charge

R. C. DAHLBERG, B.S. in Agr., Seed Analyst

DIVISION OF RESEARCH IN AGRICULTURAL ECONOMICS

L. D. H. WELD, Ph.D., Agricultural Economist

DIVISION OF SOILS

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

\*GEORGE W. WALKER, B.S. in Chem., Assistant Soils Chemist

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

DEFOREST HUNGERFORD, B.S., Assistant Soils Chemist

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

DIVISION OF VETERINARY SCIENCE

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

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

H. P. HOSKINS, V.M.D., Assistant Veterinarian

L. E. WILLEY, D.V.M., Assistant Veterinarian

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

\*J. T. E. DINWOODIE, D.V.M., Assistant Veterinarian

†H. KERNKAMP, D.V.M., Assistant Veterinarian

FORESTRY INVESTIGATIONS

E. G. CHEYNEY, B.A., Forester

J. P. WENTLING, M.A., Associate Forester

J. H. ALLISON, M.F., Associate Forester

W. H. KENETY, M.S., in Charge of Cloquet Station

ROBERT WILSON, B.S. in For., in Charge of Morris Station

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

\* Resigned during the year.

† Elected to assume duties during the year.

LETTERS OF TRANSMITTAL

MINNEAPOLIS, MINN., June 30, 1914

To His Excellency, Adolph O. Eberhart,  
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, 1914.

Respectfully,

B. F. NELSON,  
President Board of Regents

UNIVERSITY OF MINNESOTA,

MINNEAPOLIS, MINN., June 30, 1914

The Hon. B. F. Nelson, 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, 1914.

Respectfully,

GEORGE E. VINCENT,  
President of the University of Minnesota

UNIVERSITY FARM, ST. PAUL, MINN., June 30, 1914

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

SIR: I have the honor to hand you herewith the annual report of the Agricultural Experiment Station of the University of Minnesota for the fiscal year ending June 30, 1914.

Respectfully,

A. F. WOODS,  
Director

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THE MINNESOTA AGRICULTURAL EXPERIMENT STA-  
TION IN ACCOUNT WITH THE UNITED  
STATES APPROPRIATIONS, 1913-1914

Dr.

To receipts from the Treasurer of the United States in accordance with the appropriation for the fiscal year ending June 30, 1914, under Act of Congress approved March 2, 1887..... \$15,000.00

Cr.

By Salaries .....	\$8,724.97	
Labor .....	2,980.03	
Publications .....	925.00	
Postage and stationery.....	209.97	
Chemical supplies .....	289.55	
Seeds, plants, and sundry supplies.....	279.55	
Fertilizers .....	52.28	
Feeding stuffs .....	292.62	
Tools, implements, and machinery.....	443.25	
Furniture and fixtures.....	2.70	
Scientific apparatus .....	411.71	
Live stock .....	275.00	
Traveling expenses .....	60.23	
Buildings and lands.....	53.14	
	<hr/>	
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, 1914, under the Act of Congress approved March 16, 1906. \$15,000.00

Cr.

By Salaries .....	\$13,155.01	
Labor .....	1,040.25	
Postage and stationery.....	50.24	
Chemical supplies .....	218.02	
Seeds, plants, and sundry supplies.....	68.09	
Feeding stuffs .....	178.57	
Tools, implements, and machinery.....	46.50	
Furniture and fixtures.....	15.75	
Scientific apparatus .....	125.07	
Traveling expenses .....	102.50	
	<hr/>	
Total, Adams Fund.....	\$15,000.00	\$15,000.00

**FINANCIAL STATEMENT**  
**STATEMENT OF RECEIPTS AND DISBURSEMENTS, EXCLUSIVE OF**  
**BUILDINGS, OF THE DEPARTMENT OF AGRICULTURE,**  
**FOR THE FISCAL YEAR 1913-1914**  
**GENERAL SUPPORT**

DIVISION	EXPERIMENT STATION		
	Receipts	Disbursements	Net Cost
Agricultural Economics.....		\$3,097.98	\$3,097.98
Agricultural Education.....			
Agronomy and Farm Management.....	\$227.69	10,959.04	10,731.35
Agricultural Engineering.....		10,366.00	10,366.00
Plant Pathology and Botany.....		3,820.11	3,820.11
Chemistry.....		3,397.59	3,397.59
Soils.....		4,330.97	4,330.97
Dairy and Animal Husbandry.....	6,047.23	18,717.00	12,669.77
Entomology.....		1,341.02	1,341.02
Horticulture.....	280.75	4,140.56	3,859.81
Veterinary.....	3.00	3,076.07	3,073.07
Forestry.....		1,800.00	1,800.00
General Station.....	235.15	32,999.84	32,764.69
General School and College.....			
Coal.....		18,890.14	18,890.14
<b>Total.....</b>	<b>\$6,793.82</b>	<b>\$116,936.32</b>	<b>\$110,142.50</b>
Northwest School and Experiment Station.....	\$11,010.67	\$48,526.31	\$37,515.64
West Cent. School and Experiment Station.....	7,422.34	31,545.28	24,122.94
North Cent. School and Experiment Station.....	6,500.45	13,094.49	6,594.04
Northeast Experiment Station.....	2,423.46	39,018.14	36,594.68
Southeast Experiment Station.....	4,070.05	5,038.48	968.43
<b>Total.....</b>	<b>\$31,426.97</b>	<b>\$137,222.70</b>	<b>\$105,795.73</b>

**SCHOOL AND COLLEGE**

	Receipts	Disbursements	Net Cost	Total
Agricultural Economics.....				\$3,097.98
Agricultural Education.....		\$8,156.80	\$8,156.80	8,156.80
Agronomy and Farm management.....		10,959.04	10,959.04	21,690.39
Agricultural Engineering.....		10,366.00	10,366.00	20,732.00
Plant Pathology and Botany.....		3,820.11	3,820.11	7,640.22
Chemistry.....		3,397.60	3,397.60	6,795.19
Soils.....		4,330.97	4,330.97	8,661.94
Dairy and Animal Husbandry.....	\$6,047.18	18,717.00	12,669.82	25,339.59
Entomology.....		1,341.03	1,341.03	2,682.05
Home Economics.....		22,556.68	22,556.68	22,556.68
Horticulture.....		4,140.55	4,140.55	8,000.36
Veterinary.....		3,076.07	3,076.07	6,149.14
Forestry.....		1,800.00	1,800.00	3,600.00
General Station.....				32,764.69
General School.....	22,379.07	32,999.85	10,620.78	10,620.78
Coal.....		18,890.14	18,890.14	37,780.28
<b>Total.....</b>	<b>\$28,426.25</b>	<b>\$144,551.84</b>	<b>\$116,125.59</b>	<b>\$226,268.09</b>

**FEDERAL FUNDS, 1913-1914**

	Morrill	Nelson	Hatch	Adams	Total
Agronomy and Farm Management.....		\$2,450.00			\$7,529.97
Agricultural Education.....	\$1,100.00	1,100.00	\$3,979.97		1,100.00
Agricultural Engineering.....		6,900.00			6,900.00
Chemistry.....		3,000.00	1,015.00		4,015.00
Dairy and Animal Husbandry.....	1,700.00	3,000.00	3,182.61	5,663.35	13,545.96
Entomology.....	1,200.00	1,400.00	1,000.00	1,889.85	5,499.85
Home Economics.....		1,150.00			1,150.00
Horticulture.....		1,800.00	600.00		4,050.00
Plant Pathology and Botany.....	1,000.00	1,000.00		\$2,351.28	4,351.28
Soils.....	1,000.00	500.00		1,700.00	3,200.00
Veterinary.....		1,000.00	1,297.42	1,735.52	4,032.94
School and College.....		1,700.00			1,700.00
Experiment Station.....			3,925.00		3,925.00
<b>Total.....</b>	<b>\$6,000.00</b>	<b>\$25,000.00</b>	<b>\$15,000.00</b>	<b>\$15,000.00</b>	<b>\$61,000.00</b>

SPECIAL STATE APPROPRIATIONS

DISBURSEMENTS FOR MAINTENANCE, 1913-1914

Eradication of noxious weeds.....	\$1,473.21
Farm management .....	5,494.20
Tobacco investigation .....	1,606.73
Field crops .....	8,992.99
<b>Total, Agronomy and Farm Management.....</b>	<b>\$17,567.13</b>
Agricultural Engineering investigation.....	974.85
Drainage problems .....	2,252.21
Repairs .....	18,562.85
<b>Total, Agricultural Engineering.....</b>	<b>21,789.91</b>
Plant diseases .....	2,238.71
Seed analysis .....	1,497.45
Seed inspection .....	5,000.00
Bacteriology investigation .....	1,120.66
<b>Total, Plant Pathology and Botany.....</b>	<b>9,856.82</b>
Alcohol investigation (discontinued).....	120.73
Grain laboratory .....	2,437.91
Sorghum syrup .....	993.27
<b>Total, Chemistry .....</b>	<b>3,551.91</b>
Soil investigation .....	2,014.28
<b>Total, Soils .....</b>	<b>2,014.28</b>
Campus improvement .....	3,237.61
Fruit breeding .....	5,833.55
Fruit farm maintenance.....	2,097.58
Horticultural crops .....	3,872.89
<b>Total, Horticulture .....</b>	<b>15,041.63</b>
Animal nutrition investigations.....	4,516.25
Dairy extension .....	3,542.96
Live stock .....	6,072.03
Poultry extension .....	6,523.06
<b>Total, Dairy and Animal Husbandry.....</b>	<b>20,654.30</b>
Investigation of injurious insects.....	3,365.86
<b>Total, Entomology .....</b>	<b>3,365.86</b>
Forestry .....	18,467.24
<b>Total, Forestry .....</b>	<b>18,467.24</b>
Marketing and agricultural organizations.....	2,119.85
<b>Total, Agricultural Economics.....</b>	<b>2,119.85</b>
Hog cholera .....	6,268.28
Hog cholera serum.....	32,185.47
<b>Total, Veterinary .....</b>	<b>38,453.75</b>
Library .....	9,556.51
<b>Total, Library .....</b>	<b>9,556.51</b>
Agricultural Extension .....	66,819.14
<b>Total, Agricultural Extension.....</b>	<b>66,819.14</b>
Bee-Keeping .....	2,860.07
<b>Total, Bee-Keeping .....</b>	<b>2,860.07</b>
<b>Total, Special State Appropriations.....</b>	<b>\$232,118.40</b>

DETAILED STATEMENT OF SPECIAL STATE APPROPRIATIONS

	Appropriation	Balance Aug. 1, 1913	Receipts	Total Credit	Disbursements	Balance Aug. 1, 1914
Eradication of noxious weeds .....	\$1,000.00	\$1,009.03	\$291.26	\$2,300.29	\$1,473.21	\$827.08
Farm management .....	4,500.00	.....	1,000.04	5,500.04	5,494.20	5.84
Tobacco investigations.....	2,000.00	938.81	16.90	2,955.71	1,606.73	1,348.98
Field crops.....	6,500.00	1,896.74	2,274.03	10,670.77	8,992.99	1,677.78
<b>Total Agronomy.....</b>	<b>\$14,000.00</b>	<b>\$3,844.58</b>	<b>\$3,582.23</b>	<b>\$21,426.81</b>	<b>\$17,567.13</b>	<b>\$3,859.68</b>
Agricultural Engineering investigations .....	\$1,000.00	\$282.88	.....	\$1,282.88	\$974.85	\$308.03
Drainage.....	2,500.00	915.88	.....	3,415.88	2,252.21	1,163.67
Repairs.....	17,500.00	1,226.86	\$1,947.43	20,674.29	18,562.85	2,111.44
<b>Total Agricultural Engineering.....</b>	<b>\$21,000.00</b>	<b>\$2,425.62</b>	<b>\$1,947.43</b>	<b>\$25,373.05</b>	<b>\$21,789.91</b>	<b>\$3,583.14</b>
Plant diseases.....	\$2,000.00	\$68.47	\$268.75	\$2,337.22	\$2,238.71	\$98.51
Seed analysis.....	1,500.00	.....	.....	1,500.00	1,497.45	2.55
Seed inspection .....	5,000.00	.....	.....	5,000.00	5,000.00	.....
Bacteriology investigation.....	1,500.00	.....	.....	1,500.00	1,120.66	379.34
<b>Total Plant Pathology and Botany.....</b>	<b>\$10,000.00</b>	<b>\$68.47</b>	<b>\$268.75</b>	<b>\$10,337.22</b>	<b>\$9,856.82</b>	<b>\$480.40</b>
Alcohol investigations.....	.....	\$120.73	.....	\$120.73	\$120.73	.....
Grain laboratory.....	\$2,500.00	17.90	\$26.45	2,544.35	2,437.91	\$106.44
Sorghum syrup .....	1,000.00	.....	.....	1,000.00	993.27	6.73
<b>Total Chemistry .....</b>	<b>\$3,500.00</b>	<b>\$138.63</b>	<b>\$26.45</b>	<b>\$3,665.08</b>	<b>\$3,551.91</b>	<b>\$113.17</b>
Soil investigations.....	\$2,000.00	\$72.10	.....	\$2,072.10	\$2,014.28	\$57.82
Campus improvement .....	3,000.00	281.32	.....	3,281.32	3,237.61	43.71
Fruit breeding .....	5,500.00	407.69	\$8.50	5,916.19	5,833.55	82.64
Fruit Farm maintenance.....	2,000.00	640.80	791.30	3,432.10	2,097.58	1,334.52
Horticultural crops.....	2,500.00	1,102.85	542.85	4,145.70	3,872.89	272.81
<b>Total Horticulture .....</b>	<b>\$13,000.00</b>	<b>\$2,432.66</b>	<b>\$1,342.65</b>	<b>\$16,775.31</b>	<b>\$15,041.63</b>	<b>\$1,733.68</b>



DETAILED STATEMENT OF SPECIAL STATE APPROPRIATIONS—Continued

Animal nutrition investigation	\$3,500.00	\$621.31	\$2,393.43	\$6,514.74	\$4,516.25	\$1,998.49
Dairy extension	3,000.00	624.45	2,439.97	3,624.45	3,542.96	81.49
Live stock	4,000.00	2,519.61	1,000.68	8,959.58	6,072.03	2,887.55
Poultry extension	5,000.00	1,206.60		7,207.28	6,523.06	684.22
Total Dairy and Animal Husbandry	\$15,500.00	\$4,971.97	\$5,834.08	\$26,306.05	\$20,654.30	\$5,651.75
Investigation of injurious insects	\$3,500.00	\$9.10		\$3,509.10	\$3,365.86	\$143.24
Forestry School instruction	\$15,500.00	\$556.26	\$149.75	\$18,666.79	\$18,467.24	\$199.55
Forestry School support		119.07				
Timber preservation		2,341.71				
Total Forestry	\$15,500.00	\$3,017.04	\$149.75	\$18,666.79	\$18,467.24	\$199.55
Marketing investigations	\$3,000.00			\$3,000.00	\$2,119.85	\$880.15
Library	\$9,000.00	\$1,693.52	\$8.73	\$10,702.25	\$9,556.51	\$1,145.74
Agricultural Extension	\$62,000.00	\$916.94	\$4,097.81	\$67,014.75	\$66,819.14	\$195.61
Bee-Keeping	\$3,000.00		\$6.00	\$3,006.00	\$2,860.07	\$145.93
Hog cholera	\$2,000.00	\$4,305.15		\$6,305.15	\$6,268.28	\$36.87
Hog cholera serum	10,000.00					
Special appropriation	15,000.00			34,126.65	32,185.47	1,941.18
Total Veterinary	\$27,000.00	\$4,305.15	\$9,126.65	\$40,431.80	\$38,453.75	\$1,978.05
Grand Total	\$202,000.00	\$23,895.78	\$26,390.53	\$252,286.31	\$232,118.40	\$20,167.91

CLASSIFIED STATEMENT OF DISBURSEMENTS FOR DEPARTMENT OF AGRICULTURE, 1913-1914

	Sub-stations	University Farm
Salaries	\$44,392.56	\$278,572.41
Labor	24,136.08	83,496.45
Publications	44.35	8,780.41
Postage and stationery	2,753.93	10,298.28
Freight and express	1,686.93	2,706.94
Heat, light, water, and power	5,569.45	39,271.47
Chemicals and laboratory supplies	362.21	6,226.37
Seeds, plants, and sundry supplies	5,438.59	14,913.24
Fertilizers	6.82	218.13
Feeding stuffs	6,713.25	19,003.05
Library	642.94	3,664.10
Tools, machinery, and appliances	3,876.38	6,334.26
Furniture and fixtures	1,008.66	9,777.76
Scientific apparatus	28.84	3,197.96
Live stock (including hogs for hog cholera work \$19,407.96)	4,379.97	23,756.50
Traveling expenses	2,567.48	27,217.32
Contingent expenses	671.55	2,773.40
Buildings and land (exclusive of special appropriations)	32,942.71	14,398.51
	\$137,222.70	\$554,606.56
		137,222.70
Total University Farm and Substations		\$691,829.26

GENERAL SUMMARY OF DISBURSEMENTS FOR YEAR 1913-1914

	General Support	Special	Federal	Total
Agricultural Economics	\$3,097.98	\$2,119.85		\$5,217.83
Agricultural Education	8,156.80		\$1,100.00	9,256.80
Agronomy and Farm Management	21,690.39	17,567.13	7,529.97	46,787.49
Agricultural Engineering	20,732.00	21,789.91	6,900.00	49,421.91
Bee-Keeping		2,860.07		2,860.07
Plant Pathology and Botany	7,640.22	9,856.82	4,351.28	21,848.32
Chemistry	6,795.19	3,551.91	4,015.00	14,362.10
Dairy and Animal Husbandry	25,339.59	20,654.30	13,545.96	59,539.85
Entomology	2,682.05	3,365.86	5,499.85	11,547.76
Forestry	3,600.00	18,467.24		22,067.24
Home Economics	22,556.68		1,150.00	23,706.68
Horticulture	8,000.36	15,041.63	4,050.00	27,091.99
Soils	8,661.94	2,014.28	3,200.00	13,876.22
Veterinary	6,149.14	38,453.75	4,032.94	48,635.83
Library		9,556.51		9,556.51
Agricultural Extension		66,819.14		66,819.14
General Station	32,764.69		3,925.00	36,689.69
General School	10,620.78		1,700.00	12,320.78
Coal	37,780.28			37,780.28
Total maintenance—University Farm	\$226,268.09	\$232,118.40	\$61,000.00	\$519,386.49
Plus receipts	35,220.07			35,220.07
	\$261,488.16			\$554,606.56

SPECIAL APPROPRIATIONS FOR BUILDINGS AND IMPROVEMENTS FOR BIENNIUM 1913-1915

Home Economics Building .....	\$75,000.00	
Gymnasium and Drill Hall.....	90,000.00	
Trolley line .....	60,000.00	
Ice house and cold storage plant.....	20,000.00	
Greenhouse and equipment.....	22,000.00	
Addition and alterations to Veterinary Pathology Building .....	18,250.00	
Addition to horse barn.....	5,000.00	
New poultry house.....	4,000.00	
Alterations to Chemistry Building.....	3,100.00	
Addition to Dairy Hall.....	2,000.00	
Plant Pathology field house.....	2,000.00	
Alterations to Dining Hall.....	1,500.00	
Storage cellar .....	500.00	
Renewal of equipment for Boys' Dormitory.....	2,500.00	
Campus grading, fences, etc.....	15,000.00	
Timber purchase at Cloquet.....	8,600.00	
Addition to Heating Plant.....	26,000.00	
Total University Farm .....		\$355,450.00
Heating plant and water softener.....	\$40,000.00	
Drainage, sewer, and greenhouse.....	19,700.00	
Grain storage and cleaning plant.....	6,000.00	
Machine shed, corn crib, and scales.....	2,000.00	
Swine barn addition.....	1,000.00	
Grading farm and school grounds (Available 1912) ..	2,000.00	
General improvements and repairs.....	10,000.00	
Boys' Dormitory .....	40,000.00	
Total Northwest School and Experiment Station Alterations, Repairs, and Equipment.....	\$18,000.00	120,700.00
Total West Central School and Experiment Station .....		18,000.00
Purchase of live stock.....	\$2,000.00	
Clearing land .....	3,000.00	
Total Northeast Demonstration Farm and Experiment Station .....		5,000.00
Feeding-sheds and yards.....	\$1,500.00	
Superintendent's House .....	3,000.00	
Alterations and remodeling old buildings.....	3,500.00	
Drainage .....	1,000.00	
Water system .....	500.00	
Fencing .....	1,000.00	
Institute Hall .....	6,000.00	
Purchase of live stock.....	2,000.00	
Purchase of seeds and plants.....	500.00	
Total Southeast Demonstration Farm and Experiment Station .....		19,000.00
Total .....		\$518,150.00

REPORT OF THE DIRECTOR

Considerable progress was made during the year in adjusting the work of the divisions to the plan of organization described in the last and previous reports. As the department grows and more funds become available, it will be possible to assign workers more definitely to special branches. Our experience, however, indicates the economy and efficiency of a divisional grouping on the basis of subject-matter. This makes it possible to bring to bear on the problems of any one line the combined judgment of all of the specialists in that line, at the same time permitting individuals to give the major portion of their time to a single branch. Special mention should be made of the reorganization of the work in bee culture. This work is organized as a distinct division.

There were comparatively few changes in personnel during the year. W. H. Frazier and G. W. Walker resigned from the Division of Soils and their places were filled by C. O. Rost, M.A., and R. A. Gortner, Ph.D. J. O. Rankin resigned as editor and his place will be filled by W. P. Kirkwood, B.A., formerly country life editor of the Minneapolis Journal. L. E. Willey resigned from the Division of Veterinary Science to accept an appointment at Iowa State College. J. T. E. Dinwoodie resigned to accept a position with a serum manufacturing company, and H. C. Kernkamp was appointed in his place. R. C. Ashby, Professor of Animal Husbandry at the Washington State College, was appointed to the Section of Animal Husbandry in place of W. F. Hagerman, resigned, and O. B. Jesness, B.Agr., was appointed Assistant in Marketing in the Division of Research in Agricultural Economics, beginning July 1. Arrangements were made for the transfer of A. J. McGuire on August 1, from Grand Rapids Substation to the Central Agricultural Extension Office, and Otto I. Bergh, B.S.Agr., Agronomist at the Crookston Station, was made Superintendent of the Grand Rapids Station. F. L. Kennard was appointed Agronomist at the Crookston Station.

On May 4, Professor T. L. Haecker, head of the Division of Dairy and Animal Husbandry, reached the age limit, but in view of the fact that he had extensive experiments in animal nutrition not yet completed, the Board of Regents authorized him to retain temporary supervision of the work of the division. As soon as practicable he will give his entire attention to research work in Animal Nutrition.

As stated in the last report, several appropriations for new buildings were granted by the Legislature of 1913. The Home Eco-

nomics Building has been erected and is ready for equipment. The Chemistry Building has been remodeled and arranged to accommodate the Division of Soils and the Division of Chemistry. An addition has been built to the Power House and the old plant remodeled, the fire risk being as a result greatly reduced. Under the new plan new sections may be added to the Power House as needed. The old horticultural greenhouses are being replaced by new structures of concrete with steel frame throughout, and additional houses for the use of the Divisions of Agronomy and Farm Management, Plant Pathology and Botany, Entomology, and Soils are under construction. A storage cellar in connection with the soils greenhouse was also provided for. The addition to the horse barn was completed and a new brooder-house added to the poultry equipment. A double set of adjustable fittings enables us to use this as a cockerel or a laying house when not needed as a brooder-house. The grading in front of the new Engineering Building was completed and much of the farm refenced. The construction of the Plant Pathology field house has been delayed, owing to the pressure of other construction work. The Veterinary Pathology Building was also delayed as the question of location has not yet been settled, and the future handling of the hog cholera work had to be considered in this connection. Plans for the ice and cold-storage house were completed and it is expected that the building will be ready by December 1.

At Crookston a central heating plant was completed and most of the buildings were connected with it. A grain storage and cleaning plant costing \$6,000 was completed during the year; also a machinery shed, a swine barn, and a small greenhouse. The sewer connection with the city sewer of Crookston was also completed.

At Duluth considerable land-clearing and general experimental work were done. Two cottages, two barns, a hog barn, a milk house, and a machine shed were erected during the year.

At Waseca an Institute Hall and feeding sheds and yards were completed. Alterations of old buildings and reconstruction of the barn were also finished. A new well was dug on the demonstration section of the farm. Considerable drainage was installed and a large amount of fencing completed. Plans for the superintendent's house were also made and approved.

No buildings were constructed at Morris or Grand Rapids.

Additional help is needed at the Experiment Station to provide for the increased demands in Agricultural Economics, Agronomy and Farm Management, Agricultural Engineering, Plant Pathology and Botany, Entomology, Soils, and other divisions. The Power House should be completed on the lines of the new construction. The

old blacksmith shop should be repaired and remodeled for the use of Agronomy, Entomology, and Plant Pathology. A fire-proof vault should be provided for the Plant Pathology records. Considerable grading will be necessary around the new gymnasium and much road improvement should be provided for. A general laboratory building is a necessity, and a seed-house for storing and cleaning seed produced for distribution is highly desirable. The present hog cholera serum plant has a maximum capacity of 5,000,000 cubic centimeters of serum. The plant was constructed originally for experimental purposes. The plan for its enlargement is on the basis of temporary construction, owing to the fact that it can not be continued on an enlarged scale in its present location. If the manufacture of serum is to be continued by the Experiment Station, a suitable plant will have to be constructed immediately. It is urgently recommended, however, that this work be transferred from the Experiment Station to the State Department of Agriculture, if such is established, and that the plant be located somewhere in connection with the Union Stock Yards so that the cost of securing hogs for the work may be reduced and carcasses of the virus hogs suitably disposed of. At the present time it is necessary to burn the carcasses, but at the stock yards these could be disposed of to a rendering plant at a saving of several thousand dollars a year.

Additional land, as stated in previous reports, is needed for the use of the Station. The Quinn farm of 80 acres, which has been rented for several years, may be sold. This land has been used for the production of silage and for the growing of increase stocks of seed wheat, seed oats, and Minnesota No. 13 corn. One of the series of fertilizer plots was also on this tract as there was no other land available for such work. With the exception of the dairy pasture, which is suitable for no other purpose, and the land devoted to campus and necessary paddocks, all of the land owned at University Farm is used for strictly experimental purposes, such as pathological and entomological experimental plots, rotation plots, soil-fertility plots, cultural and variety tests, horticultural plots, and seed-breeding plots. Fodder corn, hay, clover, and grains are grown in part on rented land, but most of the grain used for feed is necessarily purchased. It has been necessary to place some of the experimental plots on rented land, as described above, but this is an unwise proceeding. In the case of the Quinn tract, cited above, we have lost practically all we have put into the fertilizer work on that land owing to the fact that it is now to be sold. It should be said also that some ordinary crops are grown on the trial grounds for the purpose of keeping the land clean and providing necessary rotation, but this only keeps

the land in condition for investigational work and is not to be interpreted as an ordinary farming operation.

#### PUBLICATIONS

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

##### EXPERIMENT STATION SERIES

Bulletin 136. Rope and Its Uses on the Farm, by J. B. Frear, Division of Agricultural Engineering. 20,000 edition.

137. Minnesota Wheat Investigations, Series II. Marquis Wheat; History and Culture, by A. C. Arny, Assistant Agriculturist, Division of Agronomy and Farm Management; and Milling Quality, by C. H. Bailey, Cereal Technologist, Division of Agricultural Chemistry. The edition of 5,000 is now exhausted.

138. A Study in Cereal Rusts, Physiological Races, by E. C. Stakman, Assistant Plant Pathologist, Division of Plant Pathology and Botany. 5,000 edition.

139. Minnesota Weeds, Series II. Description and Identification, by W. L. Oswald, Assistant Botanist, Division of Plant Pathology and Botany; and Eradication, by Andrew Boss, Chief of the Division of Agronomy and Farm Management. 20,000 edition.

140. Investigations in Milk-Production, by T. L. Haecker, Dairy and Animal Husbandman. 20,000 edition.

141. The Acridiidae of Minnesota, by M. P. Somes, formerly of the Division of Entomology. 3,000 edition.

142. Selection and Preparation of Land for Cranberry Culture, by C. L. Lewis, Division of Agricultural Engineering. 5,000 edition.

##### AGRICULTURAL EXTENSION SERIES

##### MINNESOTA FARMERS' LIBRARY

A full list of the titles of the bulletins published in the Minnesota Farmers' Library, or Agricultural Extension Series, will be found in the report of the Division of Agricultural Extension. In the same report is a brief statement regarding publications sent to such special classes as the teachers of rural schools and the editors of papers who wish agricultural material for their columns.

#### DIVISION OF AGRICULTURAL CHEMISTRY

R. W. THATCHER, Chief

At the beginning of the fiscal year the work of the former Division of Agricultural Chemistry and Soils was segregated into that

of two separate divisions, and all the projects of the former combined division which dealt with problems other than those directly connected with soil studies were assumed by the Division of Agricultural Chemistry.

Provision for several graduate students to act as research assistants during the year made it possible to enlarge the scope of the investigational work on several of the projects. Two of the projects, which from their nature require extensive investigation of underlying scientific principles, were organized into a series of sub-problems, some of which were assigned to these assistants as special research problems. In addition to their work on these special problems these men were required also to assist in the accumulation of the analytical data covering the economic phases of the projects with which they were associated.

A considerable quantity of special apparatus, such as is necessary for the scientific investigations above mentioned, was purchased during the year, and a large number of files of journals and recent reference books in the general field of biochemistry were added to the reference library of the division.

The division is urgently in need of better laboratory facilities for research work. The laboratories now occupied were originally equipped almost exclusively for students' practice work, largely in elementary agricultural chemistry, and hence are not well adapted to research work. The present Agricultural Chemistry Building is not well suited to research work and better quarters for the Divisions of Agricultural Chemistry and Soils should be provided, with better facilities for their research work, at the earliest possible opportunity.

*Cereal and flour investigations*—The general purpose of the cereal and flour investigations is to make a thorough study of the properties of grain and of the factors which influence such properties; and to consider the qualities affecting the commercial uses of grain, at the same time giving some attention to methods of grading grain in the market. These investigations have been divided into several sub-projects as follows:

Sub-project: *Control work for state departments*.—The State Board of Grain Appeals submitted forty-one samples of wheat for testing and analysis. The results of these analyses and tests were reported to the Board and used by them in their determination of the market grade of the sample. The work for the State Board of Control has included the analysis and testing of one hundred and six samples of flour. The results of these tests are used by the Board in letting the contracts for purchases of flour for the state institutions which are under their supervision.

Sub-project: *Wheat survey of the State.*—One hundred and seventeen samples of wheat were secured from localities representing all the typical wheat-growing districts of the State and submitted to regular analyses, and milling and baking tests. The results of these tests have been included with those of similar tests on samples of the crops of 1912 and 1913 and prepared as a bulletin which is now in process of publication.

Sub-project: *The milling value of winter wheat.*—Thirty-two of the above-mentioned samples were of fall-sown wheat. In connection with these, climatic data were secured from the nearest weather bureau stations and such other information as might have a possible bearing upon the influence of environmental conditions on the quality of fall-sown wheat. The average quality of the winter wheats of the crop of 1913 was found to be superior to that of similar wheats of the crop of 1912, but inferior to that of the spring-sown varieties grown in the same locality.

Sub-project: *Wheat storage investigations.*—The wheat storage investigations, arrangements for which were completed just prior to the close of the preceding fiscal year and described in the report for that year, were carried out on a large scale during the present year. Seventeen carload lots of wheat, having moisture contents varying from 12.75 per cent to 17.45 per cent, were under investigation at the elevator during the fall months. Several bins of very damp wheat were carried through the entire winter and the conditions under which such wheat could be stored were investigated. The laboratory work included two series of determinations of the comparative rates of respiration of wheats of varying moisture content. A method for the removal and quantitative determination of the evolved carbon dioxide and water has been worked out.

These investigations are not yet completed, but much valuable information has been secured and is being reported to the State Grain Inspection Department and utilized by it in its grading rules. The laboratory results are opening up a very promising field of study of the changes involved in the "sweating" and "heating" of stored grain.

*Coöperative wheat investigations.*—This project has for its general purpose a study of the chemical composition of wheat and the factors which influence it, from the standpoint of the principles which affect plant growth in general and that of the wheat plant in particular. The work has been divided into sub-projects as follows:

Sub-project: *The influence of environment upon the composition and milling quality of wheat.*—Samples of the four leading varieties of spring wheat, Bluestem, Velvet Chaff, Fife, and Marquis, were

grown by the Division of Agronomy and Farm Management on their experimental plots at University Farm and at Crookston. Climatological data and the crop history of the plots were recorded. The samples were submitted to careful analyses and milling tests. The data are on file for comparison with similar data for preceding and subsequent seasons.

Sub-project: *Progressive development of the wheat kernel.*—Several hundred individual heads of each of two varieties of wheat, Turkey Red and Bluestem, were tagged when first coming into bloom and samples were collected at regular intervals until the grain was ripe. These samples were immediately dried, threshed out by hand, and the kernels weighed and submitted to complete analyses. By this means the successive changes in both the percentage composition and the actual quantities of materials in the kernels were followed. The data thus secured show some unexpected and rather surprising facts concerning the composition of the daily gain in materials for successive periods of development. These results indicate the desirability of repeating the investigation and of extending it to include a study of the progressive changes in composition of the different parts of the wheat kernel during its development. Accordingly, plots of four varieties of grain have been planted and will be sampled at harvest time for the investigations of the coming year.

*The "strength" of wheat flour.*—A study of the strength of wheat flour includes a study of all the various factors which may possibly enter into it. The project has been organized into the following sub-problems:

1. The enzymes of the normal wheat kernel; their isolation, identification, and effect upon baking values.
2. The enzymes of germinated wheat; their action as yeast stimulants, and their effect upon the constituents of the kernel and the keeping quality of flour.
3. Changes in composition of dough during fermentation.
4. The yeast food value of various electrolytes and colloids, and of different flour constituents, with check baking tests.
5. Dialysis of flour and wheat products.
6. The effect of electrolytes upon the quality of gluten.
7. A study of the constitution of proteins of wheat from flours of different origins and qualities.
8. The preparation and study of synthetic flours.
9. The physical constants of different grades of flour; conductivity, freezing point, osmotic pressure, index of refraction, and specific gravity of flour extracts.

The work this year was confined to two of these sub-problems, namely, the enzymes and the proteins. The work on the enzymes has

dealt, thus far, only with the diastases and the invertases. Quantitative methods for the extraction and estimation of the comparative strength of these enzymes have been perfected. A determination of the diastase content of a large number of flours of varying strength showed that there is no definite relation between the amount of diastases present in the different flours and their relative baking strength, but indicated that there might be other factors which influence the diastatic activity of each individual flour. These are to be given further study. A determination of the invertase content of each flour showed that the amount present in flour is relatively so much less than that in yeast that the invertase content of flour is probably not a factor in its strength. The work on the proteins has developed proper methods for the extraction and purification of individual wheat proteins. A study of the cleavage products of these proteins is now under way.

*Sorghum sirup industry in Minnesota.*—The investigations of the sorghum sirup industry have been actively prosecuted during the last year as follows:

(a) The statistical data which have been obtained show that in most instances the manufacture of sorghum sirup is in a very primitive stage of development. In the few cases where records of cost are available, it appears to be an exceedingly profitable business with an assured market for a largely increased output.

(b) Analytical data concerning the composition and changes in composition of the juice of the sorghum plant during its development, accumulated during two growing seasons, with similar data for the third season which are now being secured, will permit general conclusions concerning the proper stages of growth for the harvesting of the crop for sirup manufacture.

(c) A method for the determination of the individual organic acid of the sorghum juice has been perfected and a study of the development of these acids and their effect upon the process of manufacture and the quality of the resultant sirup is being investigated. Incidentally, the development of the glucoside which yields hydrocyanic acid was studied and the stages of growth at which the sorghum plant is likely to be poisonous to stock were determined.

(d) A study of the progressive development of the different sugars in the sorghum plant is under way.

*Sodium silicate as an egg preservative.*—The investigations conducted last year were repeated this year and led to the following definite conclusions:

(a) The water glass on the Minnesota market is practically all obtained from the same source, is of two or three grades, but has a comparatively limited range of alkalinity.

(b) Within a much larger range of alkalinity than that exhibited by market samples of sodium silicate solution, the preserved eggs are not appreciably affected.

(c) Deposition of silicate from solution depends upon the exposure to the air and the amount of carbon dioxide present.

(d) Deposited silicate may be redissolved by boiling with a little lye, a method which can be used by any housewife, and such solutions are equal in every respect to fresh solutions.

(e) The relative value of a solution which has been used through a season can be readily ascertained.

*Wild rice investigations.*—Samples of the wild rice plant were secured directly from the lakes where it is grown, and samples of commercial stocks of the material as prepared for food were secured from four localities. These have been submitted to thorough analyses. The data secured furnish detailed information as to the composition of the product as it is now being prepared for human food. Studies of the possibility of more sanitary methods of preparation were temporarily discontinued because of the absence of the member of the Division of Agronomy and Farm Management who is coöperating in the investigations, but will be resumed next year.

*Grains grown in mixture.*—A study of the effect upon the compositions of the grain and straw of several cereals when grown in mixtures of varying proportions was inaugurated this year. The various mixtures were grown and harvested and the proportion of grain and straw of each kind carefully determined, by the Division of Agronomy and Farm Management. Eighty-four samples of these grains and straws have been received at this laboratory and are in process of analysis.

*Analytical service for other divisions.*—In addition to the work upon the definitely formulated projects of this division, a considerable amount of analytical work is done each year for other divisions of the Station. During the last year this work included the analysis of samples of tops and roots of inoculated and uninoculated alfalfa plants, and determinations of the percentage of dry matter in twenty samples of forage crops for the Division of Agronomy and Farm Management; and determinations of the dry weight of sixty-three samples of corn grown in the boys' and girls' corn-growing contest, for the Division of Agricultural Extension. Indications are that the volume of this analytical service which will be required by other divisions will be considerably increased in the coming years.

## DIVISION OF AGRICULTURAL ENGINEERING

JOHN T. STEWART, Chief

During the year it has been necessary to give a great deal of attention to equipping the new Agricultural Engineering Building. For this reason no progress has been made on the projects to determine the strength of drain tile or the method and cost of drainage construction.

The irrigation experiment in coöperation with the Division of Irrigation Investigations, United States Department of Agriculture, and the Division of Plant Pathology and Botany, is being continued.

One assistant spent the entire summer of 1913 in traveling over the State and collecting information on the project to determine the values and methods of improving peat and muck lands, but these data have not yet been compiled.

## DIVISION OF AGRONOMY AND FARM MANAGEMENT

ANDREW BOSS, Chief

During the year 1913-1914 the Division of Agronomy and Farm Management was reorganized into the following sections:

Coöperative Seed Production and Distribution, in charge of C. P. Bull.

Farm Crops, in charge of A. C. Arny.

Cereal-Breeding, in charge of T. B. Hutcheson.

Cost-Accounting, in charge of F. W. Peck.

University Farm, in charge of Chief of Division.

Farm Organization, in charge of Chief of Division.

T. B. Hutcheson resigned at the close of the year. His place was filled by the appointment of H. K. Hayes, New Haven, Connecticut, who will take charge of the section of Cereal-Breeding on January 1, 1915.

## SECTION OF COÖPERATIVE SEED-PRODUCTION AND DISTRIBUTION

Owing to the fact that Mr. Bull was on leave of absence to act as Secretary of the National Corn Show at Dallas, Texas, little work was done in coöperative seed-production during the year. The pure seeds grown at University Farm were sold in small quantities to farmers in Minnesota and a seed-exchange bureau was maintained through the section office. In this way material aid was given to those in search of improved strains of small grains and corn. The work is to be enlarged, the purpose being to organize into an experimental

union the students of the School and College of Agriculture and the farmers of the State. As a step in this direction several community seed clubs were formed during the year.

*Community corn-breeding investigations.*—The community corn-breeding stations have been maintained throughout the year and variety tests and ear-to-row breeding plots conducted.

*Coöperative production of sugar beet seed.*—For the last two years investigations in the production of sugar beet seed have been conducted in coöperation with the Minnesota Sugar Company of Chaska. A little more than an acre was planted to beets of different varieties at Chaska in 1913 and a large number of "stecklings" were grown, from which seed-production has been attempted this year. The results at Chaska and at University Farm indicate that sugar beet seed of good quality can be produced in Minnesota. It is proposed to enlarge this work sufficiently to determine whether or not the growth of sugar beet seed in a commercial way would be profitable.

*Tobacco-growing.*—Investigations in tobacco-growing, authorized by the state legislature under a special appropriation, were also continued through the year. A good crop was secured and considerable advance made in methods of harvesting and marketing the product. Better prices were secured last year than have ever been secured since tobacco-growing was begun in Sherburne County. No attempts have been made at tobacco-breeding, efforts being concentrated on methods of growing, cultivating, harvesting, and curing the crop.

## SECTION OF FARM CROPS

*Investigations with small grains.*—The investigations with small grains include a number of experiments, all dealing with the yield and the culture of the crop. They include: trials of acclimated versus imported seed oats; a comparison of the value of different grades of seed oats; a comparison of the value of primary and secondary oat kernels for seed purposes; a comparison of small, medium, and large grains of wheat for seed purposes; a grain-mixture test; and the relation of methods of preparation of the seed bed to the yield and quality of spring wheat. Data are being secured also on the time to sow rye and winter wheat, and variety tests of grain are being conducted. The crops are just being harvested at the close of the year.

*Forage-crop investigations.*—Several experiments are under way: (1) A comparison of the distance apart to plant corn in order to secure maximum yield, and the stage of maturity at which to cut for silage purposes. This project is being conducted in coöperation with the Dairy Division which will make the digestion experiments and chemical analyses. (2) Time, rate, and method of seeding alfalfa. This is a continuation of work started two years ago. While the tests

are not yet complete they indicate that inoculation is highly important in securing a stand of alfalfa in Minnesota; also that summer seeding of alfalfa on clean land is desirable, especially where there is difficulty in getting a stand. Different methods of inoculation are being tested and lime has been used on some plots with very beneficial results. (3) Investigations of Sudan grass, recently introduced by the United States Department of Agriculture, have been conducted for the last two years. This grass grows very luxuriantly and seems to be suited to our soil and climatic conditions. Its feeding value is yet to be determined. (4) Miscellaneous experiments in the production of millet, mixtures of Canada field peas and oats for silage, hay-production, the production of roots for feed for live stock, and investigations of the time, rate, and method of seeding sweet clover, have also been carried on.

#### SECTION OF CEREAL-BREEDING

*Cereal-breeding.*—The cereal-breeding described in previous reports has been continued throughout the year. The hybrids of 1907 from winter and spring wheat crosses are developing several good strains that give promise of being superior varieties. Selections of winter wheat for hardiness and yield have been continued and especial attention has been given to securing heavy-yielding strains of spring wheats. Selections of oats for hardiness and yield have also been continued. The work in barley-breeding has been carried on in coöperation with the Bureau of Plant Industry, United States Department of Agriculture.

Four new projects were started in plant-breeding during the year: (1) Importance of show-points and their relation to yield in corn. (2) Earliness in corn as affected by cross-breeding, temperature at which germination is made, the use of commercial fertilizers, and cultural methods. The behavior of early-maturing selections under changed environment is also being studied. (3) The improvement of small grains through hybridization and by supplementary selection. Especial attention is given to isolating plant characters and to studying their behavior in the light of the Mendelian hypothesis. (4) The interrelation between nitrogen-fixing bacteria of alsike, medium red, white, crimson, and sweet clover, and alfalfa.

#### SECTION OF COST-ACCOUNTING

*The cost of producing farm products.*—Two statistical routes, one at Cokato and one at Halstad, have been maintained throughout the year. We have also secured, in coöperation with the Office of Farm Management, United States Department of Agriculture, data from nine additional farms. During the winter feeding season data were

secured from eleven farms on which cattle and hogs were fed with a view to determining the cost of meat-production. Data have also been secured from six market gardeners in the vicinity of Minneapolis which will be combined with the data secured during the last two summers to furnish information on the cost of producing garden products. Data on the cost of producing Minnesota farm crops for the period 1908 to 1912 have been compiled for publication.

#### SECTION OF FARM ORGANIZATION

*Crop rotation experiments.*—The Field C rotation experiments have been continued through the year, thus completing the fourth cycle of the standard rotations and the twentieth year of the investigation. Upon the completion of the chemical analyses, the results for the entire period will be reviewed and published. While these experiments were expected to run only for the twenty-year period, the results obtained and the conditions of the plots at the present time seem to warrant further continuation of the work. Before the experiments are discontinued studies of the bacteria and chemical condition of the soil should be made.

The Field T plots started in 1909 are also giving valuable results. Data from five years of cropping are on file and those on certain features are ready for publication.

*Eradication of noxious weeds.*—The investigation of methods of eradicating quack grass, conducted on a forty-acre tract at Monticello, are being closed this year. The effort has been to eradicate the quack grass without losing a crop from the land. This has been accomplished through the use of short rotations and by giving thorough tillage at every opportunity when crops were not growing. The results have been highly satisfactory and will be published in the near future.

Some work has been done in the eradication of Canada and sow thistles. The plan is to close up the work on quack grass eradication and devote the next series of experiments to the control of these noxious weeds.

*Equipment of farm units.*—Very little work has been done on this project during the year. We have at hand data representing a survey of 120 farms in Minnesota, which were gathered in coöperation with the United States Department of Agriculture.

*Farm management surveys.*—In 1913 data were secured from 650 farms in Rice County. No additional field work has been done this summer, owing to lack of funds. The data secured in 1913 have been compiled, however, and will be ready for publication shortly. In order to secure the information needed we should have four men in the field each summer from May 1 to August 1. The data secured in



such work are very valuable in analyzing the farm conditions in the State and in furnishing working plans to farmers.

#### DIVISION OF BEE CULTURE

FRANCIS JAGER, Chief

Sixty-four hives and selected strains of bees were secured and considerable necessary equipment. Space for the department was set aside in the old Agronomy wing of the Farm House, and the cellar of the Farm House will be used for winter quarters for the bees. Considerable progress has been made in experimental work, especially along the line of the production of queens and of pure-line breeding, artificial fertilization having been accomplished in several cases.

#### DIVISION OF ENTOMOLOGY

F. L. WASHBURN, Chief  
ORGANIZATION

During the last year plans for the reorganization of the division were completed. Four sections were made: Vertebrate Pests of the Farm, Mill and Warehouse Insects, and Nursery and Orchard Inspection, F. L. Washburn, Chief of the Division, in charge; Spraying and Tree Insects, A. G. Ruggles in charge; Field-crop Pests and Parasites, C. W. Howard in charge; and Truck-Crop and Greenhouse Insects, William Moore in charge.

The administration of the division is in the hands of a committee composed of heads of sections, with Chief of Division as chairman.

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

Experiments are under way to devise means of economic control of field mice, including a study of the mice fauna of Minnesota and the relations which the life histories of the various species may have to measures of control. Rat and mouse virus and poisoned bait have been tested.

A study of the Hymenoptera (Bees, Ants, and Wasps) of Minnesota is well under way, large collections having been made in various parts of the State. Specimens have been mounted and classified, and the species not named made ready to send to specialists in the various groups for identification.

The work in nursery inspection has increased materially within the last year, about 101 certificates of inspection having been issued to nurserymen. Of foreign stock 439 cases were inspected, principally

from Belgium, France, Germany, Holland, and England. This represented a total of approximately one hundred thousand plants from foreign countries. All fees received for nursery inspection and granting of certificates are turned into the state treasury.

#### SECTION OF SPRAYING AND TREE INSECTS

Practically all of our spraying experiments are carried on in cooperation with the Division of Plant Pathology and Botany. A number of experiments on spraying potatoes for the potato beetle were conducted in different parts of the State, which proved that of the three insecticides, used at the usual rate, arsenate of lead was better than either Paris green or arsenite of zinc.

Arsenate of lead and iron sulphide were tried on apple trees as a spray against plum curculio. The arsenate of lead proved the better of the two.

On plum trees, working against the same insect, arsenate of lead proved its superiority over arsenite of zinc and iron sulphide.

#### SECTION OF PARASITES AND FIELD-CROP PESTS

*House fly*.—The work on the house fly has been carried over from the previous year, the University Farm being the location of the investigations. Attempts were made to find some substance which would prevent flies from breeding in manure piles. Observations were also made on disposal of garbage as related to breeding of flies. The question of hibernation was also given consideration.

*Biting stable fly*.—Very little attention has been given to the study of the stable fly, but as it is closely related to the house fly in breeding habits, considerable field data were gathered while following the work on that insect. The work will be continued another season.

*Mosquito*.—The work on the mosquito was confined to field observations in the vicinity of the Twin Cities. The breeding-places of our common species and methods of control which are applicable to local conditions were studied. The work will be continued.

*Trombidium*.—The purpose of the study of the *Trombidium* is to work out the life-history of the "jigger-mite" which is a pest in the vicinity of many of our lakes. This will give a clue to methods of control. It is extremely difficult work but considerable advance has been made. At least two more seasons will be necessary to complete the investigation.

*Orthoptera*.—The study of the orthoptera has been carried over from the last grasshopper outbreak. A few new observations have been made but the project can not be completed until another grasshopper outbreak.

*Clover seed chalcid*.—The study of the life history of the clover

seed chalcid was continued, together with a search for natural parasites which might be of use in its control. Field experiments were conducted to determine the effect of different methods of handling the crop on the amount of infestation of the seed. We hope to complete the work by the end of this season and publish a complete report.

*Wheat stem maggot.*—Data were collected on the amount of damage done to crops by the wheat stem maggot. Investigations were also made to determine its food plants, especially among the wild grasses, and to determine its methods of hibernation.

#### SECTION OF TRUCK-CROP AND GREENHOUSE INSECTS

The work during the last year was started in October. During the first part of the winter the work consisted of straightening out the insectary records and establishing a new system of keeping records. This work is still incomplete, but it is hoped this year to have all the past records, together with their specimens, on a uniform system.

During the summer the general breeding work of the insectary was taken care of, a large number of insects in various stages having been bred out for determination. The cucumber beetle and its control have been studied and the insect carried through its life cycle. That it can be effectively controlled has been clearly demonstrated.

*Fumigation investigations.*—The main project of this section has been fumigation of greenhouses with hydrocyanic acid gas. The object of this work was to ascertain what conditions influence the success of treatment, from a scientific standpoint. It is divided into the following studies: (1) How the cyanide gas penetrates a plant and what external physical conditions influence its entrance; (2) what occurs in the plant after the cyanide gas has penetrated, and what conditions affect this action; (3) how cyanide gas penetrates insects and what factors influence its penetration; (4) what occurs after it has penetrated the insect and what factors influence its action. This work is far from complete but valuable data have been obtained.

*June beetles.*—During late May and June large numbers of June beetles were out and an effort was made to obtain them from different parts of the State in order to acquire data on the distribution of the different species and the years when they will appear. The life cycle of these beetles is such that, with this information, one can predict an outbreak of white grubs. Experiments were started to breed this insect through one complete life cycle but owing to the heavy rains of the summer most of the insects were killed, only one pot containing white grubs surviving the summer.

*Cabbage and onion maggots.*—An effort has been made to obtain a more satisfactory treatment for these two serious pests. Very little

progress was made, as the land where the experiment was conducted was not sufficiently infested, but some encouraging results were obtained.

#### DIVISION OF DAIRY AND ANIMAL HUSBANDRY

T. L. HAECKER, Chief

Work on the projects on "Nutrient Requirements in Meat-Production" and "The Composition of Steers at Various Stages from Birth to Block," has progressed very satisfactorily. During this investigation there have accumulated incidentally a large amount of data on the feed required in steer-production, from birth to block; and data affording comparison of summer pasturing followed by stall-feeding with continuous stall-feeding from birth.

During the coming year the division will begin a series of experiments with swine covering the same lines of investigation.

Some special studies will be made in the application of our present knowledge of feeding to the feeding of yearling steers and lambs for market, and to the rearing and feeding of horses.

#### ANIMAL HUSBANDRY SECTION

*Maintenance of dry brood sows.*—The swine investigations during the last year were a continuation of work done the previous year, namely, a comparison of pasture plants for maintaining dry brood sows. The results during the last year were very similar to those reported in the Twenty-first Annual Report. The results emphasize further the importance of providing suitable pastures for brood sows, as this practice means the saving of much grain ordinarily required in the dry lot.

*Lamb-feeding.*—During the winter of 1913-1914, a lamb-feeding experiment was conducted, the object of which was to compare rations suitable for mutton-production in Minnesota. One hundred good western lambs were purchased at South St. Paul, and were fed for a period of 120 days. This experiment will be repeated before final results are published.

#### DAIRY HUSBANDRY SECTION

*Creamery management investigations.*—The conviction has been growing among some creamery operators that to read the fat in the Babcock test from the extreme top of the column would indicate the receipt of more fat than can possibly be recovered, not only with cream, but with whole milk as well, and that to charge the butter-maker with receipt of such an amount of fat would be to necessitate a lower percentage over-run. The demand made by creamery managers

that the butter-maker show an over-run of from 21 to 22 per cent when receiving whole milk has been known to encourage under-reading of tests. Some operators have advised the use of amyl alcohol or some other meniscus-destroying material in the reading of milk samples. The question of reading naturally involves the question of the amount of fat recovered as butter and the various losses of a mechanical nature in the process of butter-making.

These questions have been studied during the last summer in the state creamery at Albert Lea. Briefly, it may be stated that the result of the season's work supports the general teaching that in reading the fat in milk samples all of the meniscus should be included and that the difficulty often experienced by operators may have been due to the running of the centrifuge at too low a rate of speed. Unless the machine is run with sufficient rapidity to generate the required force, there will be a small quantity of moisture in the column of fat and an inaccurate test will be the result.

When cream is received at the factory, it has been found that scales not sufficiently sensitive have caused trouble by requiring more than the desired amount of cream and thus increasing the fat reading.

The principles and methods heretofore advocated were shown to be correct while the apparatus and the methods employed need improving.

*Contagious bovine abortion.*—This investigation, which is being conducted in coöperation with the Division of Veterinary Science, was commenced in the autumn of 1911, in an observational manner and with limited tests on young cattle. In the spring of 1913 four heifers were purchased to be used for this investigation. Since then the group has been enlarged. The results secured are very encouraging. Abortion can now be regularly produced in laboratory animals with almost one hundred per cent certainty. The presence of the disease in cows can be determined by a test of the blood.

#### ANIMAL NUTRITION SECTION

*Investigation in animal nutrition.*—The studies with steers in relation of food to product have been continued. The animals in Group VI, having reached an average weight of about 1,140 pounds, were sold, after one steer had been taken out for slaughter and analysis. Group VII was divided into two lots. One steer was slaughtered and analyzed and then Lot I was continued in stall-feeding while Lot II was sent to Waseca to be pastured during the summer months.

A preliminary report on the composition of steers at various ages, from birth to 1,400 pounds, is being prepared.

*Corn silage.*—Corn was planed in three ways: (1) drilled in rows 3 feet 6 inches apart, plants 7 inches apart in rows; (2) drilled

as above, except that plants were from 2 to 3 inches apart in rows; (3) checked 3 feet 6 inches apart, 4 plants to the hill. This corn will be harvested this fall at two stages of ripeness: (a) when kernels glaze, (b) when kernels dent. The corn will be cut for silage and later used in digestion experiments. The object is to determine which method of planting and cutting will return the greatest yield of net nutriment.

#### POULTRY SECTION

*Economic study of duck culture in small flocks.*—From feeding records kept at University Farm this season it would appear that in flocks of 20 or more the feeder would realize about 25 cents per hour for his time, with increased returns as the number is increased. Ducks, when fed unstintingly, are ready for market in from 9 to 11 weeks.

*Cost of growing the chick during the feathering age.*—Records indicate that at this, the most expensive period of production, the cost of feed exceeds one half the lowest market price, which in this locality is usually about 16 cents per pound live weight for prime young stock.

*Cost of growing from feathering age to maturity.*—Records of the cost of growing a flock of White Leghorn males, on range, by the hopper method, are being kept. So far the flock has more than doubled in weight in 57 days and at a feeding cost of less than 7 cents per pound gained.

*Profit from hens when confined.*—At the low average price of 20 cents per dozen for the eggs produced, a flock of 39 White Leghorns shows receipts of over 30 per cent above the maximum feeding cost. That a younger flock and one that had been confined for a shorter space of time would have shown a larger egg yield is certain.

#### DIVISION OF HORTICULTURE

The Division of Horticulture is now organized into four Sections, as follows: Fruit-Breeding, M. J. Dorsey in charge; Fruit and Vegetable Investigations, R. Wellington in charge; Floriculture and Landscape Gardening, LeRoy Cady in charge; and Fruit and Vegetable Instruction, W. G. Brierley in charge.

The administration of the division is in the hands of a committee composed of those in charge of the several sections. A report of the work of each section follows.

#### SECTION OF FRUIT-BREEDING

In the Section of Fruit-Breeding the three projects which have been under way for the last three years are still in progress.

*Fruit characters.*—Special emphasis has been given this season to the study in inheritance in clonal varieties. The hybrid plums at

the Fruit Farm, which offer special opportunities for studies of this nature, have been used. The Abundance×Wolf and the Burbank×Wolf crosses were made the special objects of this study. Since spring, careful notes have been taken upon the characters of the flower, fruit, leaf, and tree. These crosses afford an opportunity of studying the inheritance of characters in clonal varieties of the  $F_1$  generation. A large part of the work has been of a statistical nature, seed, fruit, and leaf characters being analyzed largely from this standpoint. The work upon this particular lot of material is nearing completion and the results show that the inheritance of characters in the  $F_1$  generation in clonal varieties are not constant as is ordinarily expected in Mendelian phenomena.

*Sterility in fruits.*—The work on sterility in fruits is largely of a cytological nature, although some studies are being made from actual testing of pollen under field conditions. The sub-project with the grapes has been completed and a report is now in press. The work is being continued with the strawberry and the plum. While the work on these two projects at the present time is incomplete, the results to date show that the nuclei of mature pollen in both the plum and strawberry are abnormal, degenerated, and disorganized in many of the sterile or partially sterile varieties. A large amount of material was fixed during the blooming-season the past spring and the work now consists of sectioning and studying this material.

Careful study is being made of the plum hybrids at the Fruit Farm. We have crosses between several species of this genus, such as *P. triflora*×*P. americana*, *P. besseyi*×*P. americana*, the apricot×sand cherry, *P. simonii*×*P. triflora*. Many of these are showing interesting and unusual behavior in the production of pollen and pistils. The results at the present time indicate that some of our hybrids between *americana* and *triflora* are self-sterile. This observation, however, will need to be confirmed by further tests.

*Hardiness in fruits.*—Special study has been made of the general question of hardiness in fruits. Some time was spent at the Shaw Botanical Gardens last winter, doing special work from the physiological standpoint. The work of last year on the physiological behavior of dormant twigs will be continued with the object of testing further the conditions which bring about the greatest loss of water from dormant twigs. The material available for this work at the Fruit Farm is increasing from year to year. The last season notes were taken on the percentage of winter-killing on several hundred different crosses of the strawberry, as well as of the hybrid plums. The percentage of winter-killing in the strawberries varied from a perfect stand to as high as 60 per cent. Most of the varieties stood the winter well, but there was a marked difference in the percentage of killing under prac-

tically similar field conditions. Some of the plum crosses between *P. americana* and *P. triflora* have in past years been severely injured by the winter, while some have proved hardy. Some of the crosses between the Burbank and the Wolf, and the Abundance and the Wolf, have proved sufficiently hardy to suffer no injury from winters such as 1911-1912. The results of the tests of these hybrids show that when a semi-hardy variety (with respect to ability to withstand cold), as the Burbank, is crossed with a hardy variety, as the Wolf, the progeny inherit resistance to cold in different degrees. Observations on this project are extended to the seedlings which have been sent out to the trial stations.

As a result of the breeding of hardy fruits since the establishment of the Fruit-Breeding Farm in 1907, stock has been sent out to about twenty trial stations. The different sections of the State (from a horticultural standpoint) are well represented by the location of these trial stations. Each new seedling production sent out to the trial stations has received a Minnesota number. This is the same system which has been followed in the introduction of cereals from this Station. The following is a list of the new productions, with the Minnesota number and the parentage, which were sent to the trial stations for testing in 1913:

Plums—

Minnesota No. 1	Abundance×Wolf .....	3 trees
Minnesota No. 2	Parentage unknown .....	1 tree
Minnesota No. 4	Burbank×Wolf .....	1 tree
Minnesota No. 5	Burbank×Wolf .....	1 tree
Minnesota No. 6	Burbank×Wolf .....	2 trees
Minnesota No. 7	Ornamental sand cherry seed- ling .....	1 tree
Minnesota No. 17	Burbank×Wolf .....	2 trees
Minnesota No. 21	Burbank×Wolf .....	6 trees

Grapes—

Minnesota No. 1	Beta Seedling.....	5 vines
Minnesota No. 2	Beta Seedling.....	3 vines
Minnesota No. 3	Beta Seedling.....	3 vines
Minnesota No. 4	Beta Seedling.....	3 vines
Minnesota No. 5	Beta Seedling.....	3 vines
Minnesota No. 6	Beta Seedling.....	3 vines
Minnesota No. 7	Beta Seedling.....	4 vines
Minnesota No. 8	Beta Seedling.....	3 vines

Raspberries—

Minnesota No. 1	King×Loudon .....	50 plants
Minnesota No. 2	Loudon×King .....	100 plants
Minnesota No. 3	Loudon×King .....	50 plants

Minnesota No. 4	King×Loudon	100 plants
Minnesota No. 5	King×Columbia	30 plants
Minnesota No. 6	King×Loudon	100 plants
Minnesota No. 7	Loudon×King	25 plants

## Strawberries—

Minnesota No. 1	Pan American×Dunlap (Everbearing)	12 plants
Minnesota No. 2	Autumn×Dunlap (Ever- bearing)	12 plants
Minnesota No. 3	Dunlap×Pocomoko	50 plants

In the spring of 1914 the following seedlings were sent to the trial stations:

## Plums—

Minnesota No. 1	Abundance×Wolf
Minnesota No. 3	Burbank×Wolf
Minnesota No. 8	Parentage unknown
Minnesota No. 10	Burbank×Wolf
Minnesota No. 11	Parentage unknown
Minnesota No. 12	Burbank×Wolf
Minnesota No. 13	Parentage unknown
Minnesota No. 14	Parentage unknown
Minnesota No. 15	Parentage unknown
Minnesota No. 18	Parentage unknown
Minnesota No. 20	Parentage unknown

## Raspberries—

Minnesota No. 8	Columbian×Cumberland
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Breeding for hardy fruits is being continued with the apple, plum, pear, cherry, raspberry, strawberry, gooseberry, currant, and grape. A special effort has been made in the last two years to secure a representative collection of the hardy varieties of apples. A start was also made in the selection of improved types of the blueberry. Examination of a large number of wild plants shows some quite distinct types as to fruiting habit and berry. Present facilities have not permitted any breeding work with the cranberry, but it is the intention to include, as soon as possible, the cranberry in the list of fruits for improvement.

SECTION OF FRUIT AND VEGETABLE INVESTIGATIONS  
FRUIT INVESTIGATIONS

*Variety test.*—During the last year one half of the apple trees have been removed in the variety plat, called the "flat orchard," in order to permit the proper development of the remaining trees and several Hibernian and Patten Greening trees have been top-grafted to 89 supposedly hardy varieties and seedlings secured from the Canadian

Experimental Farm, Agricultural Experiment Station, and from fruit-growers. Over 95 per cent of the grafts started finely, but later many were either killed or badly injured by the blight, which was very severe. The old plum and apple orchard, situated southwest of the flat orchard, which contained many worthless and unknown varieties, was torn out and replanted with over three hundred new and standard varieties of both small and tree fruits.

*Compilation of data.*—The collecting of data regarding the origin and success of all fruits grown in Minnesota has been continued, and much valuable information has been gathered and arranged in convenient form.

*Coöperative orchard experiment.*—Arrangements have been made with the Northeast Experiment Station and Demonstration Farm at Duluth, the State Hospital for Inebriates at Willmar, and the North Central Experiment Station at Grand Rapids to test the value of sod versus tillage and the effect of fertilizers on tree growth and productivity. On the first place, the land has been cleared and the trees purchased, and the experiment will be fully under way by next year; on the second place, part of the orchard was planted this season and the remainder will probably be set out in 1915; on the last place, the orchard will be started next year. As soon as possible, similar coöperative orchards will be started in all of the fruit or prospective fruit districts in the State in order to determine the best methods of growing fruit trees under the respective soil and climatic conditions.

## VEGETABLE INVESTIGATIONS

*Influence of crossing on earliness of tomatoes and increase of yield.*—Ten  $F_1$  generation tomatoes have been carefully compared with their parents to determine the increase, if any, in vigor, productivity, and earliness. Previous work has shown one-fifth greater yield in the  $F_1$  generation than the higher-yielding parent and, if this gain is consistent, the commercial possibilities are of great importance. The total yields have not been calculated, but the quality of the fruit equals that of the standard varieties.

*Selection and breeding of squash.*—Several strains of the Hubbard squash have been tested and a selection made of several types which vary in color, shape, and wartiness. These types will be propagated and a further selection made of the desirable marketable and peculiar types. This experiment should show the inheritable types that are "bound up" in the variety Hubbard.

*Onion selection and breeding.*—Tests of a large number of varieties of onions in the last few years have shown the presence of a remarkably large number of types. For instance, within the round Red Globe type are frequently found onions varying from white to a very

dark red and from flat to bottle-shaped. A large number of these types have been selected and self-fertilized in order to determine in what manner the characters are inherited and also ultimately to secure types which possess only desirable characters. Crosses have also been made between various colored types in order to determine how the characters segregate.

*Bean and pea selection.*—Numerous individual plants of the Refugee bean and the Alaska pea were self-fertilized and the fruit kept for future work. The object of the experiment is to determine whether pure lines or strains may be isolated within the variety and, if so, how they differ. Disease-resistant and very productive beans and peas which ripen high-yielding crops at practically the same date are in demand by the canning industry.

*Potato investigations.*—(a) Hill selection. Several hundred hills of the Early Ohio and Sir Walter Raleigh varieties were dug separately in 1913 and the product of each hill planted as a unit in 1914. From the growth of the vines and the yield there are apparently marked inheritable differences in the value of individual hills. Tests of these poor, medium, and good hills will be carried on in the northern part of the State, where diseases are less abundant, and also at University Farm, and the results compared.

(b) Determination of factors that increase or maintain yield of varieties. Owing to lack of immature and good seed stock, most of the contemplated work had to be omitted this season. The continued test of the varieties which had been grown in 1912 at Moorhead, Zumbra Heights, and University Farm, and then grown under the same conditions in 1913 at University Farm has been repeated this season. Contrary to last year's results, which decidedly favored the Moorhead stock, the three lots are nearly on a par at the time of this report.

(c) Test of varieties and seedlings. A large number of seedlings produced at this Station were given further test and five of the most promising were distributed to growers throughout the State under numbers, Minnesota Nos. 1, 2, 3, 4, and 5. The promising seedlings will be given a thorough test on various soils and the remainder will be discarded. Several varieties and species were secured this season for testing and future experimental work and already many of them show indications of degenerating or running out. This deterioration will be eliminated or remedied, if possible, by further selection and the growing of seed under different conditions.

#### SECTION OF FLORICULTURE AND LANDSCAPE GARDENING

The season of 1914 has been especially good for the development of nearly all horticultural crops. All plants, shrubs, and ornamentals on the campus came through the winter in excellent condition and

have made a good growth this season. The perennial section started last year, has been enlarged and an unusually small loss has resulted from winter-killing. Many varieties have been tested for hardiness and planting purposes. The seedling peonies flowered for the third time and many good varieties have been marked for observation next season. The standard sorts have been divided and replanted for comparison with certain new varieties and seedlings.

A large number of annuals were tried again this season, both for bedding purposes and as cut flowers. Some new varieties have demonstrated their value for ornamental purposes.

The hedge plot, which was begun some twenty years ago, has been increased this season and notes taken as to the desirability of some of these plants for hedge purposes. Among the newer hedge material *Cotoneaster acutifolia* is one of the promising plants.

The plantings on the old campus have been maintained, but very few new plantings have been made on account of improvements which necessitate tearing up parts of the campus. The new part of the campus has been seeded and part of the plantings put in. Others will be set next spring. These plantings are not only for ornamental purposes, but as tests of shrubs and trees.

#### SECTION OF FRUIT AND VEGETABLE INSTRUCTION

*Pruning apples and plums.*—The pruned apple and plum trees have made vigorous growth and will be in good condition for further work the coming year. Work for the first year can be considered only as a start. The pruning must be followed for several years before definite results can be obtained. It would be desirable to obtain space for the development of a young orchard in which pruning work may be started on newly set trees and followed for a considerable length of time.

#### DIVISION OF PLANT PATHOLOGY AND BOTANY

E. M. FREEMAN, Chief

##### SECTION OF PLANT PATHOLOGY

The work on the disease survey, as shown by the increased demand for information, is growing steadily.

*Rusts of cereals.*—Laboratory and greenhouse studies on rust-resistant forms in wheat have been carried on. These indicate that resistance may sometimes be only apparent and not real, and due to extreme sensitiveness on the part of the wheat plant variety. It has also been shown that biologic forms adapt themselves to new hosts although the adaptation is very slow. The barberry plant, while it may serve as a bridging species between rusts on grasses, probably does not act

as such between the cereal rusts. Grass rusts may possibly play a considerable part in the infection of cereals. The possibilities of obtaining rust-resistant varieties by bulk and individual selection are being tested, but the work has not been continued long enough to give results.

The work on hybridizing spring and durum wheats has been continued on an extensive scale and hybrids with considerable resistance have been developed (with the cooperation of the United States Department of Agriculture). These are being tested for behavior in other localities and under varying conditions as well as for milling qualities and yield. The work on rusts will be continued during the coming year along the same lines, except that work in biochemical studies will be added, aiming toward the isolation of the physiological factors involved in disease resistance.

*Corn smut.*—A study of corn smut has been inaugurated and a few definite results were obtained. The infections seem to be more or less local and fresh spores germinate very rapidly, making the disease spread rapidly in favorable weather. A beginning has been made in the isolation of fungi from the soil, but their power of parasitism has not yet been demonstrated. This work bears on the important question of soil sanitation and rotation of crops.

*Garden truck diseases.*—The following are the more important results in the study of garden truck diseases. Under certain conditions, spraying of tomatoes is financially profitable in Minnesota. The so-called cucumber nubbin is a physiological disorder which may be induced secondarily by facultative parasites. The chief bean disease of Minnesota, bean bacteriosis, is especially virulent on "Refugee 1,000 to 1" which is the principal canning bean. Seed plot methods must be used to control the disease.

*Potato diseases.*—The work on potato diseases has progressed considerably. Experiments have shown that mercury bichloride is probably more effective in the treatment of rhizoctonia on potatoes than any of the other standard mixtures. Spraying experiments have given varying results. It is still impossible to say that spraying potatoes for diseases would pay on an average of a number of years in Minnesota. Special attention will be given to the potato work in the coming year.

*Diseases of fruit trees.*—It has been shown that a very decided difference exists in the susceptibility of various Minnesota plums to the brown rot and the indications are that this resistance is due to physiological characteristics. The apple- and plum-spraying experiments indicate a decided financial gain as a result of spraying. No great difference in the efficiency of the various spray mixtures for the diseases which occur in Minnesota has been found. Spraying for brown rot of

plums must be so planned as to make the last spray very shortly before the time the plums ripen, since they are most susceptible to the brown rot at this particular period. In the coming year, plum pocket and apple canker and the Wealthy fruit spot will be given particular attention. The work in regard to the brown rot on plums and apple- and plum-spraying will be continued.

*Tree diseases.*—Work on tree diseases has not been pushed very vigorously. Some work has been done on oak canker, and on Armillaria root rot. Material from cross-inoculations made at Itasca Park in 1911 will be collected and examined during the coming year.

*Bacteria in peat lands.*—Samples were collected from peat soils which had been cultivated for varying lengths of time and in different ways and the bacteria were isolated and compared with those from virgin peat soils. No cellulose-splitting forms were found in virgin peat soils nor in those which had been cropped for only one or two years. These bacteria were also missing in some fields which had been cropped for as long as four years.

#### SECTION OF SEED LABORATORY

During the last year the Seed Laboratory has made analyses of 5,534 samples sent in by farmers and others and of an additional 386 samples collected by the inspector. The results of these tests will be published in bulletin form according to the requirements of the Minnesota seed law. The number of farmers who are availing themselves of the opportunity of having their seeds tested is steadily increasing and the educational results have been good. The seed herbarium has been increased by 200 samples collected by members of the division and by 1,200 samples from a collection by the late Otto Luger.

In the seed studies of the year very important results have been obtained in a perfection of methods for the diagnosis between the different species of Agropyron seeds found in the common trade. It is now possible with certainty to identify quack grass in a seed mixture, even if only the individual florets are present.

The production of weed-seed cases has been continued and the demand for them has steadily increased. During the year 553 cases have been distributed. Many other states are imitating the seed cases devised here.

In the weed studies an increasingly large number of weeds have been identified for the farmers of the State. A bulletin describing 24 weeds common in this State was completed.

The beginnings of a weed survey have been made and records are being kept of the appearance and distribution of the common noxious weeds in different parts of the State.

## DIVISION OF RESEARCH IN AGRICULTURAL ECONOMICS

L. D. H. WELD, Chief

The work of the Division of Research in Agricultural Economics has been devoted largely to problems of marketing and coöperation, and much important work has been done.

*Collection of statistics of coöperative organizations in Minnesota.*—In compliance with a state law requiring the University to collect statistics of coöperative organizations, list of all such organizations were first compiled, and blank forms for reports were drawn up for each kind of organization. Reports were secured by mail, and, although some organizations did not report, the returns are sufficiently complete to make possible a more thorough statistical analysis of coöperation than has hitherto been attempted. The results have been formulated for publication under the title "Statistics of Coöperation among Farmers in Minnesota."

*Social and economic surveys.*—During the summer of 1913 surveys of two rural communities were made, consisting of exhaustive statistical and descriptive analyses of economic, marketing, and social conditions. The tabulation of the returns and writing of the reports continued throughout the academic year, 1913-1914, and the two reports are practically completed.

*The marketing of grain at Minneapolis with special reference to the Minneapolis Chamber of Commerce.*—This study was undertaken in coöperation with the Office of Markets, United States Department of Agriculture. An exhaustive report was completed and transmitted to the Office of Markets at the end of the year. This report has not been made public and there is still some question as to its final disposition.

*Studies in marketing of Minnesota farm products.*—With the help of advanced students in the Seminar in Agricultural Economics, reports on the following subjects have been practically completed and will be presented for publication: the marketing of meat; the coöperative marketing of potatoes; the marketing of poultry. Studies of fundamental factors affecting the cost of marketing farm products, and of coöperative marketing of grain in Canada have also been made.

*Investigation of rural credits in Minnesota.*—This study was undertaken in coöperation with the Rural Organization Service, United States Department of Agriculture. This investigation has been completed. The results were turned over to the Rural Organization Service to be used in an elaborate report covering agricultural credit conditions of the United States.

## DIVISION OF SOILS

F. J. ALWAY, Chief

At the beginning of the fiscal year the work on soils and fertilizers was segregated from that in Agricultural Chemistry and assigned to the new Division of Soils. Some of the projects which have reached a certain stage of completion have been discontinued, while others have been reorganized and two new ones added.

*Soil-absorption studies.*—The work in soil-absorption is a continuation of that reported last year. The first portion of the project as originally outlined has been completed and the results are being prepared for publication.

The capillary rise at 25 degrees C. of five typical liquids has been measured: (1) In the space formed by bringing three cylinders together parallel to each other and so placed that each cylinder touches two others; (2) in the space formed by four parallel cylinders so arranged that each one is tangent to two others at points 90 degrees apart; (3) in the space formed by three spheres each of which is tangent to two others; (4) in the space formed by four spheres arranged so that each sphere is tangent to two others at points 90 degrees apart. From these observations the relationship of the size of the cylinder or sphere to surface tension and observed capillary rise have been deduced.

Further work has been done with the masses of spheres of uniform size, and the minimum pore space obtainable in the process of packing together of such spheres by mechanical shock has been determined. Also the capillary rise at 25 degrees of four typical liquids in these masses of spheres has been determined and the relationship of the diameters of the spheres and the height of rise of each of the four liquids has been formulated.

It has been decided in view of the limited amount of funds for investigation and the urgent need of work along other lines to discontinue this project.

*Fertilizer experiments.*—The experimental data showing the response of Minnesota soils to the various commercial fertilizers are very limited, consisting of a considerable number of field experiments carried out in coöperation with farmers in different parts of the State eight or nine years ago, a very small number during more recent years, and a series of 21 plots with a three-year rotation of oats, clover, and corn started at University Farm in 1909. The fertilizer experiments at Crookston and Grand Rapids referred to in the last annual report, after being started in the spring of 1913 met with such unfavorable conditions that no data of value were secured.

The practice of furnishing fertilizers for experiments in coöpera-



tion with farmers was discontinued and the plans of the fertilizer experiments at Crookston and Grand Rapids will be radically changed. Experiments were started at Waseca and Morris and a new series added at University Farm. Experiments, using acid phosphate and raw rock phosphate, both alone and in combination with barnyard manure, were started at University Farm, Waseca, Morris, and Crookston on a corn-wheat-oats-clover rotation and at Grand Rapids on a corn-oats-clover rotation. At Crookston a more complete experiment, employing nitrogen and potassium as well as phosphorus fertilizers, has been started on a barley-clover-potato rotation. At Morris and Crookston plots have been seeded to alfalfa as a permanent crop, using as fertilizers, gypsum, acid phosphate, potassium sulfate, and a combination of the last two.

A single coöperative experiment is being conducted with fertilizers on mineral soils. In this the agricultural agent of Ramsey County is to keep in close observation the planting, care, and harvesting of potato, corn, and tomato crops on twenty or more small experimental tracts located in different parts of the county, while the fertilizers used are being donated by a local company.

*Peat soils.*—But very little additional laboratory work on peat soils has been done during the last year but an extensive investigation is planned for the ensuing fiscal year in the hope of classifying the Minnesota peat areas to such an extent as to permit of an intelligent application of the results obtained by the European Peat Experiment Stations.

The coöperative fertilizer experiments on peat soils referred to in the last annual report proved highly unsatisfactory, the crop being harvested on only one of the four farms.

On a small field of peat soil at the North Central Experiment Station, at Grand Rapids, experiments are being carried on during the present season using potatoes, oats, clover, and grasses. Barnyard manure, lime, steamed bone-meal, raw rock phosphate, potassium sulfate, and sodium nitrate are being used singly and in various combinations. An assistant has been detailed to keep the plots under close observation throughout the growing season and to make a careful study of the changes in the moisture and temperature conditions of the soil from day to day.

One coöperative experiment on peat soil is being conducted at Meadowlands, the owner of the land furnishing the different fertilizers. These, both with and without lime, have been applied to lettuce, cabbage, potatoes, barley, clover, and grasses.

*Composition of the soils of the different glacial drift sheets.*—The investigation of the composition of the soils of the different glacial drifts was begun during the year. Samples of soil were collected from

five virgin fields near ten towns in the most southerly tier of Minnesota counties, namely, Caledonia and Preston on the Southeastern Loess; Spring Valley on the Early Grey Drift; Albert Lea, Wells, Fairmont, Jackson, and Worthington on the Late Grey Drift; Adrian on an Intermediate Grey Drift; and Luverne on the Southwestern Loess. Determinations of the physical constants and chemical analyses of the most important constituents are being made to determine what definite connection, if any, exists between the different glacial formations and the character of the soils found upon them. The work has already been carried far enough to show that the content of phosphorus and potassium and the physical properties affecting the supply of moisture do not exhibit radical differences. However, on the basis of the lime content, the fields at Caledonia, Preston, and Spring Valley are sharply distinguished from those at Albert Lea and still farther west. All the former carry a very small amount of lime throughout the first three feet, while the latter, with certain exceptions, carry very large amounts in the third foot, considerable in the second foot, and some of them large amounts even in the first foot. No exceptions have been found to the generalization in regard to the eastern fields but several have been found to that of the western. The explanation of these exceptions remains to be determined.

*Studies of the movement of water in soils.*—The investigation of the movement of water in soils was started late in the year, and very little progress has been made. Some field studies have been made at University Farm, Crookston, and Bemidji. In addition, the physical constants of a large number of soils, including those examined in the field studies and others collected for laboratory investigations, have been determined. This study will include the lightest sands, the heaviest clays, the intermediate loams, and the different types of peat soils found in the State.

#### DIVISION OF VETERINARY SCIENCE

M. H. REYNOLDS, Chief

During the last year Minnesota has suffered very severely from hog cholera. The total losses both direct and indirect have probably amounted to not less than \$5,000,000. In view of this serious situation it seemed wise to devote the energies of our Biochemic Section very largely to the production of hog cholera serum, as provided by Chapter 313, Laws of 1913. However, considerable experimental work has been done and valuable data have been collected in connection with hog cholera and serum work.

Perhaps the most significant feature of the year in connection with serum work has been the abundant demonstration that the serum-

only method wisely used in sick herds and properly followed up by disinfection and common-sense sanitation is very effective and does not offer any possibility of spreading cholera. There has been a marked movement by those in charge of serum, state control, and extension work toward the serum-only method. This has come about through an awakening to the danger from the widespread and irresponsible use of virus.

During the year it has become plain that hog cholera virus must be much better controlled or abolished. A very rigid Federal control or the exclusion of virus from interstate traffic appears to be an immediate necessity. There has unquestionably been a great deal of illegal and irresponsible use of virus throughout Minnesota during the year and many clear cases of vaccination cholera, i.e., outbreaks started by irresponsible use of virus in connection with the serum-virus treatment have occurred.

An important experiment in the control of hog cholera on a large scale has been undertaken during the year in Renville County. This work is done in coöperation with the United States Department of Agriculture and the State Live Stock Sanitary Board. The serum-only method is being used exclusively. It is already quite apparent that when this method is intelligently used and followed by proper sanitary measures the results are extremely satisfactory.

The plan for the distribution and use of hog cholera serum was determined by the provisions of Chapter 313, Laws of 1913, which provide for a state serum plant under the control of this institution, for a sale price of one third of a cent per cubic centimeter, and for an annual appropriation to cover loss to the State in producing serum and selling it at this price.

According to the law, state serum can be supplied for use only by persons holding a permit from the State Live Stock Sanitary Board. It has been our policy to supply serum immediately for sick herds and if necessary book orders for future delivery for healthy herds where the owner wishes to immunize as a precaution, giving preference to the owner actually in trouble.

Serum produced in 1908.....	25,000 cc.
Serum produced in 1909.....	75,000 cc.
Serum produced in 1910.....	150,000 cc.
Serum produced in 1911.....	240,000 cc.
Serum produced in 1913.....	1,000,000 cc.

Estimates indicate that each dollar invested by the State in this work saves from actual death by hog cholera about \$27 worth of hogs. Each dollar expended by the owner saves about \$81 worth of hogs. Indirectly the savings amount to several times these sums,

taking into consideration the prospective value of breeding stock and immature stock lost through cholera or prematurely marketed.

The Pathology Section has been able to do a satisfactory amount of diagnostic work and has done much field work for the State Live Stock Sanitary Board. This section is able to do a very useful service for the live-stock interests of the State by coöperating in this way with the State Live Stock Sanitary Board. Incidentally this has served to promote the best possible harmony and coöperation between the two organizations.

*New pathology laboratory.*—We now have available an appropriation for a new pathology research laboratory. Plans for location and erection are under consideration so that we may reasonably expect adequate laboratory facilities in the near future.

In this laboratory and associated stables and paddocks we should be able to do competent research work with important diseases of domestic animals. These new laboratories should also give us abundant facilities for laboratory diagnostic work on a large scale for various important diseases of domestic animals like dourine, glanders, anthrax, hemorrhagic septicaemia, and infectious abortion.

*Physiology research.*—For the Physiology Section we propose to continue under an especially trained physiologist, research work with histology and physiology of hogs' blood. We will take the blood of normal hogs as a basis for work with blood of diseased hogs, particularly those affected with hog cholera.

#### BIOLOGICAL PRODUCTS SECTION

During the latter part of the summer and fall of 1913 the serum plant was enlarged by the addition of two new temporary buildings, one for tail-bleeding and one for a scale room and holding-pens, and the acquisition of the east wing of the old hog barn for a virus department. Early in the spring of 1914 a portion of the west wing of this building was turned over to our use for holding pigs used for testing serum. A new hyperimmune shed was built directly east of the main hog cholera building. This will be ready for occupancy about the first of July. This building contains 12 spacious pens that will accommodate from 125 to 175 hogs. In the southeast corner of this building a serum cellar is provided. Here about 2,000,000 cubic centimeters of serum may be stored. With the use of ice, a uniform temperature of about 50 degrees can be kept throughout the hottest weather. The outside pens have been re-fenced and leveled with cinders, and the alleys have been partially paved.

During the calendar year 1913 about 1,000,000 cubic centimeters of serum were produced. Over two thirds of this was produced during the latter half of the year. For the year 1914 it was estimated

that we would be able to produce approximately 5,000,000 cubic centimeters. The product for the first six months was as follows:

January .....	109,670 cc.
February .....	152,745 cc.
March .....	204,850 cc.
April .....	251,620 cc.
May .....	320,720 cc.
June .....	413,940 cc.
Total .....	1,453,545 cc.

The work incidental to the production and distribution of this quantity of serum is considerable. During a period of about five months, over 700 long-distance calls for serum were received. During a period of nine months about 2,700 specific letters were written, a large number of these being answers to requests for information on different phases of hog cholera and the serum treatment.

An attempt is made to secure reports on the results of State serum, and it is found that better results are obtained each year. There are several reasons for this. It is probable that the serum turned out each year is more uniform in potency because produced in larger quantities. Veterinarians are rapidly learning to recognize the proper conditions under which to use serum and hog owners are learning to appreciate the value of prompt treatment.

Records show that losses in healthy herds following the serum-virus treatment have been less than 1 per cent. Losses in infected herds following the serum-only treatment have been reduced to about 10 per cent.

During the year the State Live Stock Sanitary Board issued permits to a large number of veterinarians to use the serum-virus treatment, as their field veterinarians were unable to do all of this work. About 78 veterinarians were given permits to use the double treatment, and 41 to use Station serum for the single treatment.

During the year we have had about 20 requests for analyses or tests of so-called proprietary hog cholera cures and preventives. Hundreds of dollars' worth of these nostrums are being sold to our farmers and it is very doubtful whether any of them have any specific value as agents to combat hog cholera. Some of them undoubtedly have some merits either as condition powders or internal antiseptics. As several of these remedies had apparently given good results in field use, it was decided to do some experimental work with a few of them, as far as our limited facilities would allow. Benetol was the first to which our attention was directed. Results of these experiments are briefly summarized as follows:

(1) Benetol apparently had no immunizing value when given to healthy hogs exposed to infection.

(2) Benetol apparently had no curative value when administered to hogs in different stages of the disease.

(3) Benetol given internally by drench, unless highly diluted, is irritating to the mucous membranes of the alimentary tract.

(4) Benetol injected intramuscularly is followed by extensive abscess formation.

The second of these hog cholera cures was one known as Hudson Hog Cholera Remedy put on the market by the Northwestern Farmers' Manufacturing Company. This remedy appeared to have given extremely satisfactory results in some field trials but where no controls were kept to serve as checks. A series of experiments almost identical with those in which benetol was tried, was made and the results were very unsatisfactory. The remedy apparently had no immunizing value and except in the case of one hog, did not appear to have any value as a curative.

One other remedy was given some attention. This was a preparation called Hog Cholera Specific, distributed by a firm in Indianapolis, Indiana. It was submitted to analysis by the North Dakota Experiment Station chemists and found to contain but a small amount of iodide of potassium. The preliminary trials were in no way encouraging, and were discontinued entirely when the nature of the remedy was made known.

Data on methods of hyperimmunizing, conditions affecting potency of serum, economy of production, and the relative potency of serum produced by different hyperimmunizing and bleeding methods are constantly being studied and collected.

#### PATHOLOGY SECTION

This division, in coöperation with the Division of Dairy and Animal Husbandry, has continued the work with contagious abortion. The work in the field has consisted mainly in the collection of blood samples for the complement fixation test. This method has proved to be fairly satisfactory as a means of diagnosis and for determining also the extent of the disease in a herd. Strict sanitary measures have been advised in the handling of all outbreaks. The pathology of sterility which is one of the phenomena of abortion has been studied in regard to importance of cystic ovaries and persistent *corpora lutea*.

Twenty-two field trips in connection with infectious abortion have been made for the purpose of establishing diagnoses and to advise with the breeders and veterinarians as to best methods of control. Numerous specimens have been received at the laboratory for bacteriological and pathological examination. Some of the tissues arrive

badly decomposed which makes a diagnosis impossible. We record the most important cases:

Disease	Animal	No. specimens received
Hog cholera.....	Hogs .....	18
Hemorrhagic septicemia....	Cattle .....	8
Rabies .....	Dogs and cattle.....	12
Pseudoleukemia .....	Cow .....	1
Anthrax .....	Horse .....	1
Ascaris suillae .....	Hogs .....	3
Ascaris inflexa.....	Chicken .....	1
Amphistomum conicum....	Cow .....	1
Tumors .....	Horses and cattle.....	7*
Mesenterial emphysema....	Hogs .....	5
Necrobacillosis .....	Hogs and calves.....	4
Actinomycosis .....	Cattle .....	4
Enlarged thyroids.....	Calves .....	2
Pneumonia .....	Cows .....	2
Tuberculosis .....	Cows .....	3
Tuberculosis .....	Hog .....	1
Tuberculosis .....	Chickens .....	2
Cystitis .....	Horse .....	1
Enteritis .....	Hog .....	1
Cystic ovaries.....	Mare .....	2
Intestinal calculus.....	Horse .....	1

\* Five malignant, 2 benign.

#### PHYSIOLOGY SECTION

*Progress.*—For about nine years preceding September, 1913, research work in this section had been devoted entirely to a study of certain ventilation problems. We were endeavoring to secure information from the physiology research standpoint on a number of important questions, among which were the following:

- (a) Is the air of an unventilated stable injurious to normal confined animals?
- (b) If injurious, what is the injury and where does it occur?
- (c) Is the percentage of carbon dioxide a reliable index of impurity?
- (d) Is the oxygen content in an ordinary, unventilated stable likely to be reduced by respiration below the point of animal requirement?
- (e) What is the least amount of ventilation compatible with normal health, thrift, and profitable feeding and milking?

(f) If the air of an unventilated stable is injurious under any circumstances, what are the factors producing injury?

(g) Is there a possible laboratory method of detecting and measuring injury?

Work along this line was carried on for about nine years before it was interrupted by changes of personnel and other difficulties.

Data covering about the first four years' work have been carefully analyzed, selected, and prepared for publication. During the last year research work was begun upon the histology and physiology of normal hogs' blood, a subject concerning which apparently little reliable information is available. This will be made preparatory to similar work upon the blood of diseased hogs, particularly of those affected with cholera.

*Swamp fever.*—The work on swamp fever has been carried on in cooperation with the United States Bureau of Animal Industry and State Live Stock Sanitary Board. The work has been done almost entirely with horses and donkeys. Experimental animals are kept in an especially constructed stable. Progress has been rather slow, partly on account of the chronic nature of the disease and partly because only equines have been used for experimental purposes. A large amount of clinical data, especially of long-continued temperatures, has been collected. Data have also been collected concerning the gross and microscopic pathology of swamp fever. A considerable amount of work has been done, apparently without definite results as yet, concerning what is for the present the most urgent phase of the problem, namely, an accurate laboratory diagnosis.

The original problems undertaken were a study of virus dissemination, infectiousness, diagnosis, prevention, and treatment.

No publications have been made as yet excepting brief mention each year in annual reports by the Chief of the Federal Bureau of Animal Industry.

#### FORESTRY INVESTIGATIONS

E. G. CHEYNEY, Director

#### CLOQUET FOREST EXPERIMENT STATION

The Cloquet Forest Experiment Station, serving as it does both State and Federal Services, is confronted with a great many problems. Many of these will take years to solve. The most pressing are the securing of reproduction, either natural or artificial, upon forest lands now destitute of trees, and the determining of the proper species, stock, and methods to use on the different types of forest lands; hence the major projects deal with reforestation and nursery practice.

*Nursery.*—A nursery of a capacity of 1,000,000 trees annually has been established and experiments are now being carried on which will demonstrate the raising of a maximum stock at the least expense. These experiments include time of sowing, depth of cover, mulches, fertilizers, and preliminary treatment of seed to secure quick and even germination.

Experiments have been carried on in transplanting to secure the best stock by the quickest and cheapest method. A method of transplanting by the use of a horse and plow has been worked out, and promises to cut down the item of cost considerably.

*Planting.*—The cost and the success of planting depend a great deal upon the tools and the methods used. A tool or method which may be very successful in one situation may be very expensive and give very poor results in another. This spring a set of experimental tools was made and the cost of planting 1,000 trees in open, brushy, gravelly, rocky, and standing jack pine situations with five different makes of tools determined. The efficiency of these tools was checked by counting the number of living trees in each plot at the end of the season. The results were very conclusive. For example, the cost of planting 1,000 trees in a gravelly situation with a wedge spade was \$2, while the cost of planting 1,000 trees in a similar situation at the side of this, with a mattock, using the center-hole method, was \$4. A count of these trees in the fall showed that 91 per cent of those planted with the wedge spade were alive as compared with only 80 per cent of those planted with the mattock. In other situations, the wedge spade was not nearly so satisfactory and some other tool seemed better suited.

Another problem deals with the species to plant in certain situations and the age of the stock of each species to use. Very extensive experiments have been initiated in order to determine the right species and the proper stock for the many different conditions to be found in this neighborhood.

*Thinning.*—To determine the proper time to thin in order to do the most good at the least expense is a problem which must be worked out. Plots have been laid out in stands of different densities and these have been thinned by removing the suppressed trees. The number of trees and the amount of wood removed have been noted in each case and all remaining trees measured and numbered to be compared with check plots which have not been thinned.

*Mensuration studies.*—A great deal of northern Minnesota is swampy land which is now worthless but is suited to the growing of spruce, which appears likely to become an important industry. To find out what the growth of the natural spruce in such situations is, in order to determine what may be expected from this swampy land,

studies have been started which will determine the amount of wood produced naturally on such land and the length of time necessary to produce a profitable crop. To learn whether species of spruce not native to this region will grow faster and prove more profitable, half-acre plots, each containing 500 trees, have been planted to Norway, red, and blue spruce.

*Other experiments.*—Other experiments include meteorological studies, investigation of soil temperatures, and evaporation of moisture from the soil in the various situations in which planting or nursery work is being done. Work has been carried on in planting hardwoods and shrubs exotic to this region. The Bureau of Plant Introduction has sent many different varieties of poplar and willow from China, many of which are making very good growth and give promise of surpassing our native species.

Experiments are also well under way to determine the success of seed trees for restocking cut-over areas. The results show that only in very favorable situations will reproduction be quick but even then the price of the lumber left in the seed trees would go a long way toward paying the cost of planting the land uniformly.

The results obtained at this Station have already materially changed some of the methods used by the State and Federal Forest Services in this region, and their future practice will largely depend on the results of the experiments now under way.

#### SYLVICULTURAL STUDIES OF ITASCA PARK

The silvicultural studies of Itasca Park are carried on in connection with the regular work of the junior class in the College of Forestry and consist of forest nursery work and work in the field in various parts of the park.

*Forest nursery.*—The nursery is gradually being enlarged and improved and new species of trees, both conifers and hardwoods, are being tried out. The results of the last year, both in the seed beds and in the nursery rows, were practically destroyed by deer, rabbits, and white grubs. Seed beds containing two-year-old Norway pine seedlings were so closely cropped by deer that over 50 per cent of the seedlings were killed. Rabbits pruned and in places completely devoured some of the larger plants, particularly the European larch. White grubs devoured the roots of about 75 per cent of the white pine, white spruce, and sugar maple transplants. During the coming year the entire nursery will be enclosed by a fence which will exclude the deer and rabbits, this being necessary in order to carry on the work.

Seeds of red, white, chestnut, pin, black, and scarlet oaks from the eastern states were planted. They have grown well the first sum-

mer, but the severe test for them will come in the winter. In the spring of 1913, seeds of the pignut, mockernut, and shagbark hickories were also obtained from the East and planted at the same time. The growth of all of these species was very promising, but the tissues were not sufficiently hardened when winter came on and every seedling died. A test of butternut and black walnut seedlings from Minnesota seed shows that the butternut can withstand the winter successfully, but the black walnut is severely injured.

Experiments in collecting and handling forest-pulled stock and growing it one year in the nursery before planting in the field are in progress.

Experiments in late seeding, for the purpose of preventing damping-off in coniferous stock, have shown conclusively that during an average season white and Norway pine sown as late as July 12 have developed into sturdy seedlings capable of resisting the winter, and showed no trace of damping-off. Experiments along this line are still in progress.

A new nursery house containing seed room, tool room, seed-extracting plant and packing cellar is about completed. Experiments in extracting coniferous seed and in storing and keeping the same will be carried on.

*Field studies.*—Experiments in field planting were so badly interfered with by deer and rabbits that no results were obtained. Since Itasca Park will always be a game preserve, supporting large numbers of deer and rabbits, and it will always be necessary to carry out planting and other silvicultural work under these unfavorable conditions, intensive studies were carried on in several parts of the Park to determine the extent and severity of the damage done to natural reproduction of white and Norway pine by these animals. The injuries due to the deer consisted almost entirely of the nipping off of the ends of branches of trees up to 6 feet in height. Injuries due to rabbits were very severe and consisted of side pruning, top pruning, and complete pruning. Very little girdling was found anywhere. Many areas where white and Norway pine reproduction up to 12 inches high amounted to about 25,000 plants per acre, showed a total destruction of over 75 per cent of all of the plants. Apparently no distinction was made between the two species of pine, but the Norway, on account of its great abundance, suffered more than the white pine. Over 50 per cent of the plants on the areas studied were completely pruned, resulting in the death of the seedlings. Further study of specific injuries of this nature are planned for the future.

#### PRAIRIE TREE PLANTING INVESTIGATIONS AT MORRIS

In the fall of 1913 the requests for advice on prairie planting

and windbreaks, and the lack of definite data on these subjects, made it necessary to institute some investigations in this field. An investigator was assigned to the problem, at Morris, in cooperation with the West Central Experiment Station. The more detailed work carried out was as follows:

*Commercial nursery census.*—A circular letter was sent to the nursery firms in the State asking for their opinion as to the kinds of trees best suited for prairie planting, the best methods of setting out, spacing, and caring for trees. Some thirty nurseries responded, giving, in many cases, valuable suggestions. The answers were assembled under the different questions asked. This summary gives a very fair idea of the nursery men's knowledge of the subject.

*Field survey.*—A preliminary field survey of the four counties, Stevens, Bigstone, Traverse, and Swift, was made. About fifty farmers were interviewed, most of them on their farms, and their plantings examined. The questions asked were of a general nature, aiming to get the farmers' ideas as to the best species of trees for farm planting, the methods of planting, cultivating, etc. A preliminary report covering this work in Bigstone County has been made.

*Experimental planting.*—A plot of about two acres on the West Central Experiment Station was planted with several varieties of coniferous and broad-leaved trees. These trees were set out primarily for protection to the school campus and will be cared for with that end in view. Some interesting data, however, will be forthcoming at the close of the growing season.

The work done so far shows very clearly that reliable data can not be obtained from the study of the groves now in existence; their history is too incomplete. It will be necessary to establish a permanent station where the desired experiments can be tried with all of the factors under control. The farmers on the prairies are very much interested in this work and anxious to see such a station established.

#### DIVISION OF AGRICULTURAL EXTENSION

A. D. WILSON, Director

During the year ending July 31, 1914, the Agricultural Extension Division has had in its employ thirteen men and three women who have devoted full time to Agricultural Extension work, and six men and one woman who have devoted part time. This is in addition to the county agents, farmers' institute workers, and office force.

#### FARMERS' INSTITUTES

The Farmers' Institute work has been handled through the same organization as the Agricultural Extension work, although supported

by a separate appropriation and administered by a separate board. It is in reality but a branch of the Agricultural Extension work. Institute workers are hired by the week, largely between December 1 and April 1. Nineteen men and four women were employed.

During the year the following Institutes have been held:

	Number	Total Attendance	Average Attendance per Session
Regular Institutes . . . . .	106	59,350	182
Special Institutes, consisting of farmers' club meetings, school officers' meetings, cooperative organization meetings, etc. . . . .	675	55,359	82

Fifty thousand copies of Farmers' Institute Annual No. 26 were published and distributed free at the various agricultural meetings held in the State. Annual No. 26 was devoted quite largely to a report on farmers' cooperative movements in Minnesota, and has been of great help to communities desiring to organize along the various lines.

#### FARMERS' CLUBS

The first Extension bulletin, published January 1, 1910, dealt with Farmers' Clubs, and was widely distributed.

A good deal of attention has been given to farmers' clubs since that time, and during the last fiscal year a man was employed for full time to aid with this movement. The state high school board endorsed the movement as a desirable line of work for the high school agricultural men to encourage. Most of these agricultural instructors were reached at their annual conference, and all were reached by personal letters and, by copies of Extension Bulletin No. 46 dealing with the farmers' club movement.

Early in the year a general campaign was started with a view to getting a farmers' club in each of the 1,600 agricultural townships in the State. Town officers, rural school teachers, county superintendents, high school agriculturists, high school superintendents, and others interested in agricultural development, were communicated with, and an effort made to interest them in farmers' club work. *The Farmer*, published by the Webb Publishing Company, St. Paul, gave most excellent assistance in the work by employing a man and devoting an entire page each week to farmers' club work. Later in the year the other farm papers—*Farm, Stock and Home, Northwest Farmstead, Northwestern Agriculturist*, and *St. Paul Twice-A-Week Dispatch*—all devoted considerable space to reports from farmers' clubs.

All of the Institute work done during December, 1913, and a

large part of that done throughout the year was in connection with farmers' club meetings.

Timely topics for discussion at the meetings have been furnished monthly to the clubs in the State for nearly four years.

The farmers' club movement seemed to appeal to nearly everyone in the State. As a result, during the year nearly 700 clubs were organized. July 31, 1914, about 830 were listed with the Agricultural Extension Division.

#### SPECIAL TRAINS

During the year two special trains were operated by the division in cooperation with two railroads in the State. One was operated on the Duluth & Iron Range Railway from May 18 to May 30, 1914. One stop was made each day, and the people with the train went out into the country, visited the farmers on their farms in the forenoon, and held meetings at the train in one of the coaches in the afternoon. This train was equipped with a home economics demonstration car, and work along that line was offered, as well as along the line of agriculture. Twelve stops were made, and 2,085 people attended the lectures and demonstrations.

June 8 to June 20 another train was operated on the Minnesota & International Railway in cooperation with the Northern Pacific development agent. The train was out 12 days and made 12 stops. The train carried only dining and sleeping accommodations for those with the train. The speakers went out into the country and held meetings in various town halls, or schoolhouses, away from the railroad. From two to four meetings were held each day. Thirty of these local meetings were held, with a total attendance of 2,100.

The plan followed with these trains was entirely different from that of any previous demonstration trains, and was much more practical. The lecturers were given an opportunity to find out at first hand some of the conditions with which the people in the community had to contend, and were therefore better able to be of assistance, and could give talks that were practical for the community.

#### RURAL SCHOOL WORK

Two men have devoted practically their entire time to rural school work. They have encouraged the teaching of agriculture in the rural, graded, and consolidated schools, and have assisted materially in conducting industrial contests in nearly all of the counties.

A special effort has been made to organize boys' and girls' clubs in connection with the regular farmers' clubs of the State, and as a part of the rural school organization.

Several local school fairs have been held in connection with rural schools.

All rural school work has been conducted in close coöperation with county superintendents and teachers.

About 700 boys and girls finished the work of the acre yield corn contest conducted last year and had their yields checked. The boy who won the grand championship of the State produced 134 bushels of corn, field measure, on his acre, thereby winning a scholarship in the Minnesota School of Agriculture. The average for the 46 prize winners was 88.6 bushels, field weight, and 71 bushels, dry weight. This year 3,100 boys, representing 80 counties, have enrolled. The special work this year for the girls is a bread-making contest, with over 1,000 entries. The majority of the county agricultural societies have departments for industrial contest work, and about \$8,000 will be paid out by these associations this fall in premiums for the boys' and girls' work.

#### COUNTY AGRICULTURAL AGENTS

The county agricultural agent movement has probably grown too rapidly. A year ago there were 11 county agents in the field; at present there are 25, with two additional counties organized for the work, but for which agents have not as yet been secured.

#### FINANCES

In one county in which there is an agent, the county commissioners are making no appropriation. In two counties they are appropriating \$500 each. In the rest of the twenty-five counties, the commissioners have appropriated the full \$1,000 allowed by law. The appropriation made by the last state legislature for this work permitted the payment of \$1,000 to each of 25 counties for the fiscal year ending July 31, 1914. As some of the counties did not organize promptly on August 1, 1913, the full \$25,000 was not needed. Beginning August 1, 1914, this appropriation will be increased to \$35,000, and we do not wish to see the number increased above 35 for two years at least, or until the work is well established.

About \$5,000 of Federal funds has been received to support the work in all of the counties; but the Smith-Lever bill, which goes into effect July 1, 1914, and increased funds from the Bureau of Plant Industry, will enable us to provide \$300 of Federal support for each county. This can be increased as the Lever funds accumulate. We hope eventually to be able to pay \$1,000 out of Federal funds toward the employment of a county agent in each county. This will provide a fund of \$3,000 in each county, which is really needed to take care

of the salary, traveling expenses, and necessary office expense in connection with efficient county agent work, and will do away with the necessity of asking for subscriptions.

#### CHARACTER OF WORK

It has been necessary for county agents to devote a large part of their time to the immediate needs of the county. They have helped to control hog cholera, to introduce better seed, and better live stock; have encouraged alfalfa-growing, and the building of silos; helped in the exchange of seed and live stock between various farmers; and have assisted in the organization of numerous farmers' clubs and other coöperative organizations, and in the promotion of industrial contest work. The aim has been to get each community so organized as to be able to handle the emergency work locally, and to leave the county agent more time to develop definite farm management plans that will bring about better business organization on farms.

Through the coöperation of the United States Department of Agriculture, it will be possible during the coming year to undertake some farm management survey work among groups of farmers in each of several counties that will aid the county agents and others working with them to form a reasonable diagnosis of the situation in each county, and be able to suggest plans of improvement based on a thorough knowledge of present actual conditions. Two men will be started on this farm survey work early the following year, to assist the county agents.

#### DIFFICULTIES

The county agent work in the State has not been entirely free from difficulties. In many counties the work was established through the efforts of enthusiasts before many of the people in the county thoroughly understood the movement, or were ready to support it. County agent work is new, and even the men in charge of the work have not known how best to organize it. Men with peculiar qualifications for the work have not been plentiful. The work, however, has not been discontinued in any county, although in a few instances there has been some active opposition to it.

Results of the work on the whole have been very encouraging, and it is hoped that when the newness of the movement wears off it will become a regularly accepted and well-supported branch of the county, state, and national service to the agricultural interests.

#### SHORT COURSES

The holding of 5-day short courses in the smaller towns and cities is one of the main lines of Extension work. During the last



year more courses were held than at any previous time. Better equipment was furnished, consequently better work was accomplished. A carload of stock, consisting of a good type of draft horses and representatives of the chief dairy and beef breeds of cattle, was taken to each regular short course. During January, February, and March, three cars were on the road all of the time and traveled over 5,400 miles. These cars of stock were transported by the various railway companies without charge. At these courses there were three or more persons from the Agricultural Extension Division. Work in Home Economics was given in all but four. The main agricultural work given was along stock and farm crop lines. Regular courses were held at the following places: Adrian, Albert Lea, Annandale, Bagley, Brainerd, Brooten, Canby, Clarkfield, East Grand Forks, Excelsior, Fergus Falls, Fertile, Hallock, Hastings, Hutchinson, Lake Crystal, Lakefield, Lanesboro, Le Sueur, Litchfield, Luverne, Lyle, Madelia, Madison, Milaca, Monticello, Mora, North Branch, Park Rapids, Plainview, Rush City, St. Peter, Sauk Center, Truman, Waseca, Windom, Winthrop, and Worthington.

At Barnum and Moose Lake the week's work was divided between the two towns, and also at Bigfork and Blackberry. The total attendance was 36,800 men and 18,960 women. The several county agents held three- to five-day short courses at the following 23 places: Ada, Adolph, Beardsley, Benson, Bird Island, Browns Valley, Clinton, Dawson, Fairfax, Gary, Halstad, Hendrum, Herman, Hermantown, Jackson, Meadowlands, Molde, Palo, Redwood Falls, Renville, Wells, Wheaton, and Winnebago, with a total attendance of 18,378.

Several short courses were managed locally which were given some assistance. These were at Austin, Mantorville, and Owatonna, making a total of 68 short courses, and a total attendance, counting all sessions, of 74,128. About 6,725 different men and 2,100 different women attended these courses.

#### DEMONSTRATION FARMS

During the last year, the number of demonstration farms has been increased from 18 to 28. The owners live on the farms, and each does a man's work on his farm, has no other line of business besides farming, and farms no other area except that designated to be farmed in coöperation with the division. An inventory is taken about January 1 at the opening of each year's work. The division has a 5-year contract with each farmer, and the farmer agrees to follow the suggestions and plans of the division.

Each farm demonstrates one or more lines of work, such as methods of eradication of noxious weeds, farm drainage, farm organization, selection and management of live stock and field crops, or any

other line of work classified under farm management. Not more than one farm is located in a county. The idea in each case has been to direct the operations of the whole farm, so that the land, labor, and capital will produce maximum results.

During the year, 413 visits were made to the demonstration farms by Extension workers. The following tables show yields secured on demonstration farms compared with the average yields secured in Minnesota.

COMPARISON OF YIELDS

Crop	Number of Farms	Acres	Yield Bushels	Average Demonstration Farms	Average State
Wheat.....	15	289.5	4,891.0	16.9	16.2
Oats.....	19	506.0	21,308.0	42.1	37.8
Corn.....	19	441.4	21,377.5	48.4	40.0
Potatoes.....	16	60.33	8,333.0	137.9	110.0

COMPARISON OF DAIRY PRODUCTION—1913

Farms	Number Cows	Average Lbs. Milk per Cow	Average Lbs. Fat per Cow	Average Value
Rothsay.....	8	5,666.0	208.9	\$64.24
Hutchinson.....	10	5,625.8	219.6	75.54
Wheaton.....	8	4,849.2	196.8	60.75
Marshall.....	11	5,235.1	191.6	56.86
Belle Plaine.....	12	6,315.2	270.0	84.63
Breckenridge.....	5	6,131.7	200.0	59.21
Pipestone.....	6	5,551.2	229.4	64.81
Wadena.....	12	4,761.9	187.9	59.14
Osakis.....	11	4,786.1	186.7	61.38
Renville.....	11	6,956.6	250.4	76.63
Detroit.....	11	4,166.6	179.2	58.20
Total.....	105	60,045.4	2,320.5	\$721.39
Farm's average per cow.....		5,458.6	210.9	\$65.58
State's average per cow.....		4,000.0	150.0	47.25
Difference.....		1,458.6	60.9	18.33

#### COUNTY FAIRS

During the fall of 1913 judges were furnished for about 100 county and street fairs. This is being made more and more an educational feature of the fair, and is an excellent way of connecting educational work with a form of entertainment. Wherever possible the Judges explain their reasons for placing the exhibits, which adds greatly to the educational value of the fair. The county fair associations pay the traveling and hotel expenses, and the division furnishes

the judges. During the fall of 1913 entertainment features were furnished at 8 county fairs. The entertainment furnished consisted of the play, "Back to the Farm," for one afternoon and evening; a scientific demonstration of liquid air and the gyroscope, together with a reading, for another afternoon and evening; and a lecture for the third day. A motion picture show was kept in operation each day in a small tent. The venture was only partially successful. The fair associations paid approximately \$300 for the three days' entertainment, but this left the division with a deficit. The motion picture feature was not at all successful, because of lack of equipment.

#### SPECIAL MEETINGS

The Agricultural Extension Division is called upon constantly for assistance in connection with all sorts of meetings, such as rural school meetings, farmers' clubs, farmers' picnics, farmers' cooperative organization meetings, teachers' and school officers' meetings, and development association meetings. The division has attempted to comply with all such legitimate requests so far as facilities permit. During the year, 1,433 meetings were held, with a total attendance of 152,096.

#### PUBLICATIONS

Publication has continued along the same lines as in former years. Farmers' library bulletins have been published as follows:

44. Barnyard Sanitation, by H. Preston Hoskins.
45. Mutton, by T. G. Paterson.
46. Farmers' Clubs, by A. D. Wilson.
47. Clover, by Andrew Boss and A. C. Army.
48. Dourine, by W. L. Boyd.
49. Alfalfa-Growing in Minnesota, by A. C. Army.
50. The Seed-Potato Plot, by E. C. Stakman and R. Wellington.
51. Some Internal Parasites of Domestic Animals, by W. L.

Boyd.

52. Model Farm Houses, by Maurice I. Flagg.

The mailing list for Extension bulletins is about 45,000. Sixty thousand copies of each bulletin are published to provide a surplus for special requests. It has been necessary to reprint a large number of bulletins during the year.

Twenty-four issues, of 3,500 copies each, of University Farm Press News were published and distributed. This publication goes to local papers and to a few people in each community who are especially interested in educational work. It is not sent to farmers.

Every three weeks copy has been furnished to the American Press

Association for an illustrated agricultural page which has been used by about 50 local newspapers.

During each of the nine school months, Rural School Agriculture, in an edition of 10,000, has been published and mailed to each rural school teacher in the State.

#### SUMMER SCHOOLS

Owing to shortage of funds, the state superintendent of public instruction provided for the agricultural and home economics instruction at the county teachers' training schools this year. It is expected to continue this work next year.

#### COW-TESTING ASSOCIATIONS

Considerable time has been devoted to cow-testing association work. It is quite difficult to keep these associations alive, chiefly because of the difficulty of securing competent men for testers at the salary that the associations can pay. Only about 400 cows can be tested by one man, and the usual price for testing varies from \$1 to \$1.50 per cow. A man qualified to work out feeding rations and give advice regarding breeding, feeding, and housing of live stock, as well as to test milk, is necessary to make a success of testing-association work, and it is very difficult to get a man of sufficient training and experience for from \$400 to \$600 per year. However, some very good work has been done by these associations, of which there are twelve in the State. A report is being prepared with a view to helping in the organization of new associations.

#### LIVE STOCK SHIPPING ASSOCIATIONS

There has been an unusual demand on the division during the past year to assist in the organization of Live Stock Shipping Associations. These associations are very successful, probably because of the simplicity of their organization. No capital stock is needed, in fact all that is required is an agreement among a number of farmers that they will ship their stock through the association. A board of directors is elected, who hire a manager. The manager's salary is paid out of a commission charged on stock handled.

#### "BACK TO THE FARM"

The "Back to the Farm" play was handled by the division. Two thousand copies of the play were published. Mr. Shumway, the author, was paid \$200 royalty for the State rights. The play was given in forty-three places, and was received with great favor. We hope to be able to present it in every community in the State.

APPROXIMATE DISTRIBUTION OF FUNDS IN AGRICULTURAL EXTENSION WORK  
IN MINNESOTA FOR THE YEAR ENDING JULY 31, 1914

Kind of Work	Agr. Extension Fund	State County Agent Fund	Farmers' Inst. Fund	Office of Farm Mgt. B. P. I.	Local Funds
Demonstration farms	\$10,000				
Short courses	10,500		\$2,200		
Farmers' institutes			6,000		
County agents	4,000	\$21,767.97		\$6,960	\$26,223.25
Rural schools	6,000				
Publications	8,500		3,000		
Farmers' clubs and coöperation	3,000		3,000		
Misc. extension work	12,500		4,500		
Office expense and supervision	7,500		4,300		
Cancelled		3,232.03			
Total	\$62,000	\$25,000.00	\$23,000	\$6,960	\$26,223.25

## MEETINGS\*

Kind of Meetings	Number	Total Attendance All Sessions	Approximate Number of Individuals Attending
Regular institutes	106	59,350	23,850
Special institutes	675	55,359	55,359
Special trains (2)	42 (stops)	4,185	4,185
Regular short courses	42	55,750	6,300
Special meetings	1,433	152,096	152,096
Total	2,298	326,740	241,790

\*This does not include any part of the work of county agents.

## THE SUBSTATIONS

## NORTHWEST EXPERIMENT STATION

At the Northwest Experiment Station, at Crookston, work on rotations was continued. The major seven-year rotation has been changed to a six-year rotation with the seventh field of that series seeded to alfalfa. This was desirable for the reason that we already have a seven-year experiment rotation and needed additional land for alfalfa investigations. The fields comprising these two rotation series have been used to produce pedigreed seed. These rotations have been carried on for four years and are beginning to show decided differences. The question of weed control in connection with rotations, on land difficult to drain in this latitude, is one that will receive careful study in the future.

Fertilizer experiments, in coöperation with the Division of Soils, have been reorganized as stated in the report for that division.

A test was made as to the time of sowing winter wheat with the result that the earliest sowing produced the highest yields. This work will be continued. Minnesota Grimm alfalfa continued to show its superiority in yield and in hardiness. Alfalfa was also sown to determine the results of sub-soiling with a deep-tillage plow as compared with ordinary plowing. One half of the field was sown with a nurse crop and the remainder without.

At this Station, the most satisfactory method of quack grass eradication on fields only partially infested, has been planting the field to hill corn and subjecting the areas infested to a continuous and severe cultivation.

The rate-of-seeding tests were continued with oats and wheat but results are erratic. Variety tests were also continued. A variety test of corn was conducted in coöperation with the Division of Agronomy and Farm Management. Northwestern Dent had the highest average yield. Other work with corn for seed, feed, and fodder is in progress. Great interest is being shown in corn production in the Red River Valley and excellent results are in evidence on all sides.

The fiber flax investigation was continued and tests were made of home-grown fiber flax, Holland, and Russian. Records were kept of yield of fiber and seed per acre, and results thus far obtained appear to be very promising. This experiment is carried on in coöperation with the Bureau of Fiber Investigation of the United States Department of Agriculture.

The work in testing varieties of potatoes and testing methods of spraying and treating seed potatoes, of seed selection, and methods of planting, has been continued. The Burbank variety from new seed gave the highest yield during the last year. Last year Carman No. 3 was first. In the spraying tests no conclusive results have yet been obtained. The data on seed selection show a slight advantage for hill-selected seed as compared to storage-selected, with both of these methods far superior to selection from field-run and small potatoes. Extensive variety tests of garden vegetables have also been continued.

## WEST CENTRAL EXPERIMENT STATION

The West Central Experiment Station, at Morris, is just beginning to report progress in its experimental work.

The five-year rotation which was begun four years ago on 100 acres of land which had been very poorly farmed previous to that time and was full of weed seed, is beginning to show decided results in our studies of weed-eradication, increased yields, and general soil improvements. This year four fields out of the five were free from mustard and all were free from wild oats. Because of excessive rain during May and June, yellow foxtail became troublesome in the corn

fields, otherwise weeds have given little trouble this season. The crop yields have been steadily increasing, especially corn and clover hay. Wisconsin No. 7 corn has been used on the major rotation.

The ten-acre field of Minnesota Grimm alfalfa seeded in 1913 came through the winter with a perfect stand and this season made an average of 5 tons per acre. The variety test work was increased and the results show a greater yield for the Grimm and the Baltic. The Turkestan alfalfa gave the poorest yield. Twenty-one strains were started in the nursery this year and are in excellent shape.

This season a 4-year rotation of corn, wheat, oats, and clover, in 4 series of 18 plots each, has been started. The fertilizers used are rock phosphate and acid phosphate, both alone and in combination with barnyard manure, and barnyard manure alone. It is planned to continue this experiment for at least 8 years.

The variety work with wheat and oats was continued upon 31 plots.

#### NORTH CENTRAL EXPERIMENT STATION

The work at the North Central Experiment Station, at Grand Rapids, shows in its results that dairying for general conditions is, without any question, the most profitable system of farming and entirely practical for the majority of farmers. Hog-raising to a limited extent and poultry-raising can be carried on with dairying.

Oats, clover, fodder corn, potatoes, and rutabagas have been found the most profitable field crops for general conditions. Practically all the field crops common to Minnesota have been grown successfully on the Experiment Farm, but the crops mentioned have been most satisfactory in connection with dairying, when the amount of land under the plow is limited. Oats have produced larger yields per acre than other grain, have proved better adapted to new land, and the better quality of the straw for feeding has been of advantage. Clover has been grown with continuous success by seeding with a grain crop of any kind. On rich land it produces a limited amount of fall pasture after the grain has been cut, without injury to the next year's hay crop. It has yielded two cuttings of hay every season and has been very effective in building up the humus of sandy soil. It has been of particular value in a system of crop rotation necessary to insure large yields and keep up the fertility of the soil. Fodder corn has been of special advantage in producing a large amount of feed on a small area of land in a single season.

Potatoes have proved the most profitable field crop to market from the farm. The average yield of potatoes on the Experiment Farm for 10 years has been 225 bushels per acre. The average yield for 1911, 1912, and 1913 was 306 bushels per acre. These large yields

with a comparatively small cost of production make potatoes an especially desirable crop for a farm of limited size. In the production of roots for stock, rutabagas have been more reliable than other varieties. The seed have produced a better stand, they are hardier under unfavorable conditions during their early growth, and are more easily cared for. Roots can be made to take the place of grain to a considerable extent and the large yield secured from a small area of ground makes them especially desirable in dairying on the small farm.

The farms of the timbered section of northern Minnesota have on an average less than 25 acres under the plow. When a living must be made from this amount of cultivated land, large yields are necessary and for this reason special attention has been given to the production by practical methods of large yields in field crops. The first fact worthy of note is that as the number of cows has been increased, the yield of the field crops has increased. Through feeding all the crops produced on the farm except the potatoes and considerable purchased grain feed in addition, and carefully applying all the manure to the fields, the soil has been enriched. The Experiment Farm has had 100 acres in field crops for the past 10 years. The dairy herd has been increased from 20 to 100 head in the same length of time, 60 of which are cows and heifers in milk. This number of dairy cattle, with the horses, pigs, and poultry kept on the farm, has made the supply of manure such that each field has been manured at the rate of 12 tons per acre every third year.

#### NORTHEAST EXPERIMENT STATION

Operations at the Northeast Demonstration Farm and Experiment Station, at Duluth, have been a continuation of the development work begun a year ago. Experiments have been outlined for the coming year, to include the cropping of 10 or more acres of newly cleared land, getting the rotation in complete operation, and growing pure-bred grains. White Leghorns will be the principal breed of poultry kept and the only work attempted will be the breeding and feeding for egg-production, poultry-farm management, and demonstration of marketing possibilities of the special Farm Label and the Parcel Post. Variety tests of apples will also be taken up.

#### SOUTHEAST EXPERIMENT STATION

The Southeast Demonstration Farm and Experiment Station, at Waseca, has been divided into two tracts, a demonstration farm of 200 acres, and an experimental tract and building site of 46 acres.

The demonstration tract has been farmed during the year at some disadvantage owing to the lack of sufficient drainage. The main tiled drains and some laterals were put in last fall. A new building