EIGHTEENTH ANNUAL REPORT

OF THE

AGRICULTURAL EXPERIMENT STATION

OF THE

UNIVERSITY OF MINNESOTA,

Fiscal Year, July 1, 1909, to June 30, 1910.

Ramaley Printing Co., St. Paul, Minn.

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MINNEAPOLIS, MINN , July 1, 1910.

To His Excellency, A. O. Eberhart, Governor of Minnesota:

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, 1910.

JOHN LIND,
President Board of Regents.

List of Bulletins Published During the Fiscal Year Ending June 30. 1910.

The bulletins of this Station are mailed free to all residents of this State who make application for them.

The Minnesota Agricultural Experiment Station in Account with the United States Appropriations 1909-1910.

Dr.		
To receipts from the treasurer of the United States as per appropriation for fiscal year ending June 30, 1910, as per Act of Congress approved March 2, 1887		$15,000.00
Cr.		
By Salaries	$8849.87	
Publications	76.50	
Postage and Stationery	31.73	
Heat, Light and Water	2331.98	
Chemical Supplies	44.92	
Seeds, Plants and Sundry Supplies	358.30	
Feeding Stuffs	2297.90	
Tools, Implements and Machinery	314.99	
Furniture and Fixtures	138.00	
Scientific Apparatus	89.48	
Live Stock	135.00	
Traveling Expenses	173.18	
Buildings and Repairs	158.15	
	$15,000.00	$15,000.00

Dr.		
To receipts from the treasurer of the United States as per appropriation for the fiscal year ending June 30, 1910 under Act of Congress approved March 16, 1906		$12,774.58
To balance from appropriations for 1908-1909		225.42
Cr.		
By Salaries	$8469.92	
Labor	1144.36	
Freight and Express	34.39	
Heat, Light and Water	77.10	
Chemical Supplies	236.67	
Seeds, Plants and Sundry Supplies	69.77	
Feeding Stuffs	1284.41	
Tools, Implements and Machinery	57.79	
Furniture and Fixtures	209.00	
Scientific Apparatus	1245.63	
Live Stock	51.00	
Building and Repairs	117.95	
Balance	2.01	
	$13,000.00	$13,000.00

Financial Statement.

Statement of disbursements and receipts of the Minnesota Experiment Station for the twelve months beginning July 1st, 1909, and ending June 30, 1910 inclusive:

	Receipts	Disbursements	Cash Outlay
Agriculture	$1,540.94	$14,799.00	$13,258.06
Animal Husbandry	3,540.62	8,475.28	4,934.66
Chemistry		963.03	963.03
Dairy Husbandry		244.93	244.93
Entomology		314.95	314.95
Horticulture	971.06	2,260 82	1,289.76
Station	143.32	17,592 59	17,449.27
Veterinary	16.25	1,747.46	1,731.21
	$6,212.19	$46,398.06	$40,185.87

Crookston Sub-Station.

Balance Aug. 1st, 1909	$ 747.36		
Cash Receipts	3,995.86		
Disbursements		10,608.33	
Balance Aug. 1st, 1910		2,134 89	
	$4,743.22	$12,743.22	
State Appropriation			$8,000.00

Grand Rapids Sub-Station.

Balance Aug. 1st, 1909	$1,494.10		
Cash Receipts	4,829.95		
Disbursements		10,037.74	
Balance Aug. 1st, 1910		3,286.31	
	$6,324.05	$13,324.05	
State Appropriation			$7,000.00

REPORT OF THE DIRECTOR OF THE EXPERIMENT STATION.

To the President of the Board of Regents:

I have the honor to hand you herewith the Eighteenth Annual Report of the Agricultural Experiment Station of the University of Minnesota, for the fiscal year ending June 30th, 1910. The report covers the work at the central station, (University Farm) and the branch stations at Crookston and Grand Rapids. Four bulletins have been published during the year; and reprints are included herewith. A full account of the expenditure of the funds appropriated by the Government of the United States, for Experiment Station purposes, is presented, as well as of the expenditures for this purpose from the current expense funds of the University.

The rapid development of a more scientific agriculture is increasing the demand for more exact information in all departments of agricultural science and practice. The experiment stations are called upon, more than ever before, to furnish this information. It has been necessary for the states to appropriate large sums in addition to what the Government supplies. Every dollar so invested yields large returns, through increased production, as the result of the control of weeds, disease, and insect pests; of the better cultivation of soil by conservation methods; of the introduction of new crops, and the improvement of crops by breeding and selection; also through the control of animal diseases, the development of feeding standards, the improvements in dairy products and methods of manufacture, etc. The Minnesota Station has cooperated with the various bureaus of the National Department of Agriculture in much of this work, as will be pointed out more in detail in the reports of the divisions.

Relation of the Station to Other Branches of the Department.

The Station has very wisely conducted its investigations, in its various departments, along lines of greatest fundamental importance to the agriculture of the region. The divisions have been so organized that the work in the College, the School, the Extension Division, and the Experiment Station may be conducted in the closest co-operation. The College gives thorough training to young men and women who desire to make investigation and education their life-work. The most efficient of these students are used as assistants on the farm, in the plant-breeding nursery, or in the various laboratories, under the direction of the experts. This practical experience is a very valuable part of their training; and at the same time it gives us well-qualified labor at a comparatively small cost.

School of Agriculture.

The School of Agriculture emphasizes the practical side of farming. The students here learn the importance of experimental work in its application to actual farming. They go back to the farms and put into practice the improved methods discovered and demonstrated by the Station workers. They bring their problems to the Station workers, and thus the investigator is kept in touch with practical conditions. This practical touch is still further emphasized through the Extension and Demonstration division of the department.

This branch of the work aims to get in close touch with the farmer and his family; to study his needs, and to give him all the help possible. Through this branch of the department the valuable results of our own investigations, as well as those of others, are brought home to the farm. Problems needing further study are brought to the investigators for solution.

DIVISION OF DAIRY AND ANIMAL HUSBANDRY.

This plan of organization—insuring the greatest efficiency of each branch, as well as the whole—has been still further perfected during the year by bringing the animal husbandry, dairy, and poultry work together into a single group, known as the Division of Dairy and Animal Husbandry, including the work of the College, School, and Station. The Division is divided into the following sections: Dairy Section, Beef Section, Horse Section, Swine Section, Sheep Section, Poultry Section, etc.; with an expert at the head of each, and such specialists as are needed in the educational and investigational phases of the work.

Much more extensive work on poultry breeding, feeding and management should be undertaken at the earliest possible date. A special department, including an animal industry farm, is needed for this purpose.

Division Records.

In the division of Dairy Husbandry and Animal Nutrition, the system of keeping complete records of the feed consumed; of the milk and milk solids yielded by each animal in the dairy herd; and of the gain in live weight made by young stock—begun when the Division was organized nineteen years ago—has been continued. Tabulations have also been made of the yearly record of the dairy herd for eleven years; showing the feed consumed by each cow, and the milk and butter-fat she produced, together with the cost of milk and butter production, based upon the average farm price of feed in Minnesota. The subject is treated as a business proposition with the dairy herd.

Additional compilations have been made with respect to the food consumed by each cow, and its nutritive content, and the milk solids returned during the periods of stall-feeding each winter, up to the spring of 1909; with a view to studying the relation of food nutrients consumed to milk solids yielded. This phase of the work with the dairy herd has advanced scientific and economical feeding to a new plane; and has so simplified the art of feeding for milk production that it can be understood and practiced by the average farmer. By its use, the average

production of cows can be greatly increased and the cost materially reduced. It is expected that, when the new findings are generally understood and practiced, the profits in dairying will be practically doubled.

Bulletins covering these two phases of dairy husbandry are now being prepared for publication, and will be issued early in the winter.

With the beginning of the year 1908, a series of experiments were inaugurated with a view of making a similar study of the relation of feed nutrient to body-growth and meat-production, with steers. In this study, all feed consumed by steer calves, from birth to block, is weighed at each feeding, and samples taken for chemical analyses. A careful record is also kept of the gain in live weight, and the composition of the bodies of the steers, at certain periods of life, determined by a complete chemical analysis. From the beginning of the year 1908 to the close of the fiscal year ending July 31, 1908, six steers were slaughtered and analyzed, which ranged in weight from fifty pounds to two hundred and fifty pounds. During the fiscal year ending July 31, 1909, eleven steers, ranging in live weight from sixty-five pounds to five hundred and fifty pounds, were slaughtered and analyzed; and during the year ending July 31, 1910, seventeen steers, ranging from two hundred pounds to nine hundred pounds live weight, were likewise treated.

There is an enormous amount of labor involved in this project, but the final results will show ample justification for it; as they will have the same bearing upon economic beef, mutton and pork production as the experiments in milk production have had on the dairy industry.

DIVISION OF AGRICULTURE AND FARM MANAGEMENT.

Investigations in Agronomy have been continued on the scale outlined a year ago. The investigations in Farm Management have been emphasized somewhat, and should be still further expanded as means will allow. The work of the Division has been along the lines of (1) Plant Breeding; (2) Farm Crops; (3) Crop Rotations; (4) Cost of Production of Farm Products; (5) Weed Eradication; (6) Farm Management.

Plant Breeding.

Investigations of methods of breeding the cereals and grasses have been continued, with a view to simplifying the process of developing new varieties of farm crops.

Progress is being made by hybridizing, by selection of superior plants, and by extensive centgener trials of promising stocks. Work has been carried on with spring and winter wheat, winter rye, oats, barley, flax, millet, corn, sugar beets, alfalfa; mammoth, medium, alsike and white clover; timothy, bromus inermis, and hemp. The results of previous work in plant-breeding are evidenced in the valuable new commercial varieties now ready for introduction among the farmers of the state. We have sent out for general trial, this year, Minnesota No. 529 winter wheat, and Minnesota Nos. 261, 281 and 295 oats. A number of varieties of spring wheat have also been developed, which appear to lead all old standard nursery and commercial varieties. When propagated in sufficient quantity, they will also be offered for general growth. All of these new varieties outyield the standards by from five to twenty-five per cent.

Farm Crops.

The work with farm crops has consisted largely of variety tests, tests of thickness of seeding, time of seeding and tillage methods. Tobacco is the only new crop taken up; and work on that has been only moderately successful. In Sherburne County, a number of farmers have grown good crops, under the general supervision of Professor C. P. Bull. The trials at University Farm have not indicated that tobacco will be an especially desirable crop for Minnesota farmers.

Crop Rotation.

The studies in crop rotation have been successfully carried forward another year. The four- and five-year rotations, requiring the application of barnyard manures in reasonable quantities, and in which grass lays are included, continue to give the best yields of all classes of crops. The continuous-cropping plots, and the short-period rotations, have ceased to yield profitable returns; but are continued for the purpose of making further studies of the chemical and bacteriological conditions. The plots on which cultivated crops have been grown continuously, since 1894, are seriously depleted in vegetable matter; and the root crops are frequently attacked by a fungus, or by bacteria that destroy the crop. This phase of the rotation work should receive especial attention during the next year. One hundred and thirty-four plots are now employed in rotation experiments at University Farm; and the balance of the farm is being gradually brought to a system of management in which every field is properly included in a major scheme of rotation of crops.

Cost of Production.

The work on Cost of Production of Farm Products is continued along former lines; the statistical routes at Northfield, Marshall and Halstad being the centers of operation. Special farms at Glyndon and Morris are also included in these studies. Extensive compilations have been made during the year, covering the cost of all lines of farm products. Bulletin No. 117—published also by the Bureau of Statistics of the United States Department of Agriculture, as Bulletin No. 73—contains the results of the first six years' work, and is made a part of this report.

Weed Eradication.

The spread of noxious weeds in the state has necessitated attention to the eradication of such plants as quack grass (agropyron repens), Canada thistle, (Cincus arvensis), sow thistle, (Sonchus arvensis), wild oats, mustard, French weed and other persistent annuals. Quack grass eradication has received especial attention in plot work, in the vicinity of

University Farm and at Monticello, Minnesota. At the latter point, a forty-acre tract of badly-infested land has been rented for a period of five years, and crop rotations devised which, it is expected, will eventually result in the eradication of the quack grass without losing a single crop. Methods of bare fallowing, and of clearing the land by the use of smother and cultivated crops, are also being tried in comparison with these rotation schemes.

Farm Management Studies.

There is urgent call for information relating to the business-like management of farms, including a knowledge of types of farming, farm equipment, farm selection and planning, crop rotation, farm crops and farm animals. It is the intention of those in charge of the work to conduct these studies, so far as possible, in co-operation with farmers in various parts of the state; in the belief that the results so obtained will more nearly reflect the best farm practices. With this view in mind, work was started a year ago with Geo. Olson, at Belle Plaine, and upon Meadowlands Farm, at Meadowlands.

Work has also been started, along this line, in connection with the eighteen or twenty demonstration farms, inaugurated since March 1st, by the Extension Division of the College of Agriculture. As soon as men are available, this work should be extended to cover studies of all types of farming in the state.

Future Development.

Each line of investigation pursued in the Division should be enlarged materially. The results so far attained in plant-breeding warrant large expenditures in the further development of cereals and grasses. The importance of the work would justify the employment of at least two experts, who could devote their entire time to a study of the development of varieties of farm crops; gaining, at the same time, much scientific knowledge applicable alike to plant and animal breeding.

A soil bacteriologist should be employed at once, to study the bacterial influences affecting the growth of the crops on land producing single crops continuously. This work, and

other investigations where soil bacteria are an important factor in crop production, would fully occupy the time of a specialist in soil bacteria. If funds are not available for the employment of a bacteriologist in the Division, it may be possible to have one detailed from the United States Department of Agriculture for this special work.

More clerical help is needed in the Cost of Production investigations. A large mass of data has been gathered; which, of course, is useless until compiled into bulletins on special subjects. One such bulletin has been compiled this year. Two clerks, working full time, at a total cost of $1,200 to $1,400 per year, could compile the tables for several important bulletins on special subjects relating to crop and animal production. It is hoped that sufficient help can be employed, during the next year, to carry forward this work.

Farm Management.

The Farm Management work has but recently been started; and is, in fact, an outgrowth of the studies in Crop Rotation and Cost of Production. The work has been carried on, so far, by those engaged in the above lines. To give the needed emphasis to this line, at least three trained men are needed; one of them an expert in farm planning and crop rotations, to study conditions and give aid to farmers wishing to re-organize and re-plan their farms; one, an expert in farm machinery, to study machinery equipment for different types of farming, and to conduct investigations of the efficiency of various types of machines; and one to study special types of farming, such as vegetable and truck farming, fruit-raising or animal production. This work cannot be undertaken by our present force; and, notwithstanding its importance, must be delayed until additional help can be obtained.

Publications.

There has been published for this division, during the year, Bulletin No. 117, on the Cost of Producing Minnesota Farm Products; Bulletin No. 120, on Rye-Growing in Minnesota; and Press Bulletin No. 37. Extension Bulletins Nos. 6 and 9 have also been prepared for publication by the Extension Division.

DIVISION OF HORTICULTURE AND FORESTRY.

The State, and the Department of Horticulture and Forestry in particular, has suffered a great loss in the death of its chief, Dean S. B. Green. Prof. Green was made Dean of the Forestry Department near the close of the year; but he retained charge of the horticultural work, and the experiment station work in forestry, in the Department of Agriculture. He was one of the great builders of the institution, and his wise planning and great energy in the execution of work had much to do with the successful development of the Department. He held the highest rank as a man, a scientist and a teacher.

The work of the Division has been carried on this year much the same as in past years, except that the work along fruit lines has been and is gradually being moved to the Fruit Farm at Excelsior; and more attention is being given to plant-breeding; leaving work on the ornamental plants and vegetables to be carried on at St. Anthony Park.

The season has been the most discouraging, for experimental fruit work, we have ever known. The warm weather of March and April brought our plants into bloom unusually early, and the severe frosts injured, and in most cases destroyed, the flowers; so that no fruit set, or where it did set it dropped early. Many ornamentals were severely injured, but in most cases are recovering, and with good winter conditions will come out all right. The season has demonstrated very nicely the value of thorough preparation and constant cultivation of land for a crop.

Apples, plums, raspberries and blackberries were a total failure at the Station. Raspberries and blackberries set some fruit; but very little matured, on account of the drought. A few grapes were harvested; these were principally of the Beta variety.

Ornamentals.

Peonies did not blossom as heavily as usual, owing to frost injuries. A few of the seedling peonies blossomed for the first time. Shrubs collected from dry districts, such as Caragana, Sand-thorn, Buffalo Berry, etc., did unusually well. Tests were made of some new annuals and shrubs, and it is

planned to add many new shrubs and plants to our grounds during the next season. About three thousand Beta grapes, and a quantity of ornamentals, were distributed this spring, and more are to be sent out this fall.

Vegetables.

The potato and vegetable work, under Mr. Kohler, has been carried on as usual. About 6,500 seedling potatoes, from seed saved in 1908 and 1909, were planted. Experiments have been conducted with Bordeaux mixture, for blight. Experiments in the use of insecticides, hill selection, and studies in heredity, have been carried on. Variety tests have also been conducted.

Fruit Farm.

The work at the Fruit-Breeding Farm, at Excelsior, continues to grow in interest, and begins to give returns. A large number of strawberry seedlings were planted, and selections made from these. About 1,500 crosses of strawberries were made in the greenhouse and the seed planted. Besides these, a large number of tree fruits have been crossed in the greenhouse and the seed sown. The greenhouse has been increased to one hundred feet in length by eighteen feet in width. Considerable land has been cropped and prepared for the planting out, next spring, of seedlings of tree and bush fruits. Some 12,000 strawberry seedlings were set this season, and are doing well in spite of the drought. Several thousand plum and raspberry seedlings will fruit next season, if conditions are good.

If the work of the fruit-farm is to continue on the large scale which it deserves, more labor and land will soon have to be provided.

Needs.

Among the needs of the Horticultural Division at this time are: 1. More land for vegetable and potato work. 2. A new and enlarged greenhouse, so that some vegetable work may be done in it during the winter, and better space supplied for ornamental plants to be used in Floriculture and other classes. The present houses do not give enough space for present classes in the school and college. The side-walls,

posts, etc., are very badly decayed, making the building unsafe in case of heavy snow or wind-storms. A new building of improved construction is much needed. 3. More land should be obtained at the Fruit Farm, and more funds are needed for additional assistance to the superintendent there.

Forestry.

The experimental work in Forestry, during the past year, has been carried on mostly at Itasca State Park and at the Cloquet Forest Experiment Station.

At University Farm, the experiments in the damping off of pine seedlings, in seed beds, were seriously interfered with by the abnormal drouth conditions, which made the disease a rarity.

Some two or three thousand fence-posts were treated with cresote, in co-operation with the farmers at Lafayette, Minn., and set out where the results can be observed. The farmers there organized the first co-operative association ever formed in America for the preservative treatment of fence-posts. The posts were mostly willow and cottonwood. The open-tank process was used. The cost, a little higher than necessary in this instance, was twelve cents per post. This can easily be reduced to eight cents.

A small laboratory is now in process of construction, at University Farm, where extensive experiments in the preservation of all kinds of farm timbers can be carried on. Both the non-pressure and the pressure processes will be tried, and many kinds of preservatives tested. A rot-cellar, in connection with this plant, will very materially hasten the results of the tests. Water-gas tar has already been proven unsatisfactory, on account of the low boiling-point of the large amount of water it contains, and the consequent frothing, which causes it to overflow the tanks.

Some cedar posts, which were painted with coal tar and set in the vineyard ten years ago, have been examined and found to be perfectly sound.

At Itasca State Park, trial was made of the results obtained by the early and late sowing of pine seeds in beds. Results seem to indicate that sowing should not be done before the middle of June, on account of the damage from the spring rains, and the lack of enough heat to cause germination. Last year was such an abnormal one that results are not very trustworthy.

The experimental fire-breaks had a severe test in the many forest fires of the spring and summer. A break cleared and plowed to the width of two rods proved adequate, in every case, to stopping the flames. In no instance did the fire jump the break. In fact, it is certain that a one-rod break would be quite as effective in most cases. However, when there was a high wind, the sparks flew over the breaks for a distance of ten or twelve rods. It is not practical to make a plowed break wide enough to prevent this, but it was found that the burning of the dead brush, at a favorable time, on a strip twelve or fifteen rods wide, inside the break, with a single furrow on the inside edge of this strip, would do away with all danger from this source.

Experiments proved that the complete screening of seed-beds, both top and sides, with half-inch wire mesh, was absolutely necessary to prevent serious damage from rodents and birds. Chipmunks and red squirrels were the most troublesome before the seeds germinated. The birds damaged the young seedlings by pecking off the seed-caps before they were free from the cotyledons, thus pulling off the whole top of the seedling.

The soaking of the seed in different preparations, to protect it from these pests, was tried, but proved unsatisfactory. All the preparations of tar-oil, which kept off the rodents and birds fairly well, interfered too seriously with the germination of the seed. Red lead, about the only preparation which did not delay germination, did not keep off the rodents. Poison tablets were left untasted till the seed had been disposed of. The half-inch wire mesh gave perfect protection.

At the Cloquet Forest Experiment Station, many sylvicultural experiments have been started; but, owing to the newness of the Station, no results have as yet been obtained. A log building has been built as a headquarters, fire-breaks put

in around the boundaries, and roads repaired. These permanent improvements are necessary before experiments can be successfully undertaken. The timber owned by the lumber companies has much of it been removed under our supervision, and valuable results from some experiments along this line will soon be available.

DIVISION OF ENTOMOLOGY.

This has been a very unusual and trying year as regards insect pests. Native grasshoppers, while not reducing to any marked extent the Minnesota grain crop, have been so alarmingly numerous that individual farmers, particularly in the Red River Valley, have suffered severely. The Chief Entomologist and his assistants have been in the field at different times, instructing the farmers in the construction and use of hopperdozers, and helping them in other methods of controlling the pests, in an effort to relieve a very discouraging situation. This Division has also furnished, from its state fund, over one hundred dollars' worth of kerosene oil to farmers, free of charge, for fighting grasshoppers.

The trouble has come, in almost every instance, if not in every instance of injury, from the presence of large tracts of unused lands, held by residents and non-residents, which have once been under cultivation, and been allowed to "go back;" affording excellent opportunities for the uninterrupted breeding of these insects, which find there conditions perfect for the laying of their eggs and production of their young. We have a grasshopper law which directs the plowing of such lands; but the expense of this plowing is not put arbitrarily upon the owners of the lands, and hence, the owners or lessees are indifferent to the conditions.

In the central, south central and southern part of Minnesota, we have also suffered materially, the past year, from one of the army cut-worms, namely, Heliophila albilinea, which has originated, in every case, in timothy fields which have not been plowed for several years. This worm has destroyed,

utterly, the timothy-seed on tracts ranging from one hundred acres to fifteen hundred acres, in different localities. The following localities are places where the pest has been extremely destructive; but they do not represent all points in Minnesota which have had trouble this year from this cause: Ashby, Battle Lake, Canby, Elbow Lake, Hendricks, Heron Lake, Marshall, Murdock, Otter Tail, Revere, Ruthton, St. James, Russell, Tyler, Windom, Worthington.

A new circular, Press Bulletin No. 39, has been issued, advising our farmers of protective and remedial measures against these two very destructive insects.

With the funds provided by the Adams Act, we are working particularly upon Bruchophagus funebris, the clover-seed chalcis, which is annually responsible for the destruction of thousands of dollars' worth of clover-seed. This is our third year of work with this insect, and we are pleased to state that at present we can report material progress along this line.

This has been a very trying year on shade trees. Borers in the oak and elm have caused great destruction, as have various leaf-eating insects.

Many boxes of imported nursery stock from France and Holland have been examined; and in one case a nest of Brown-tail moths was found. It was promptly taken care of, and placed where harm could not result.

Nine thousand colored charts of insects and birds have been issued to the schools of Minnesota, under the provisions of an act at the last session of the Legislature.

About eighty Minnesota nurseries have been inspected, and those entitled to same provided with certificates of inspection, and the money received for inspection turned in to the State Treasurer.

Material additions have been made to our collection of insects this year.

In the insectary, which is proving an invaluable aid to our work, not only has the Adams Fund work upon the clover-seed chalcis taken much of the time of the men; but other experiments on the life-histories of various pests, the raising to maturity of insects sent to the entomologist, etc., have occupied the time and attention of the men.

As a result of the unusual visitations of injurious insects, this year—which have been so extremely noticeable on account of the drought—the correspondence of the entomologist has increased to a marked extent, and has continued later in the summer than ever before.

To place timely hints and suggestions promptly before farmers and fruit-growers, each month, the Division has undertaken the publication of a paper entitled, "Minnesota Insect Life," issued the first of each month during the summer, and mailed upon request to any farmer or fruit-grower of the state.

An assistant in this Division is investigating the serious damage being done to tamaracks in the state by the larch sawfly, in order to find some means of reducing its ravages.

Our entomologist was asked by the State Board of Health to visit the towns of the Iron Range, to investigate the relation of flies to a typhoid and dysentery epidemic among the mine-workers. During this visit it was found that the house fly, the so-called "typhoid fly," was undoubtedly responsible for the spread of typhoid. The conditions among the miners, as regards hygienic surroundings, were deplorable.

There has been some complaint, on the part of a few farmers, regarding the quality of Paris green. We have a law governing the character and quality of this poison and other insecticides; but its enforcement is in the hands of the State Dairy and Food Commission.

DIVISION OF AGRICULTURAL CHEMISTRY AND SOILS.

The work of this division during the past year has been largely formative in character, owing to the many changes in the laboratory staff. Professor Harry Snyder, chief of the division, resigned December 1, 1909. The present chief of the division, Prof. Hoagland, took up his work December 1, 1909.

The work of the division has been placed on a definite project basis, and substantial progress has been made on most of the projects. The projects have been outlined under two headings: First, Soils; second, Agricultural Chemistry. In brief, the projects and work accomplished are as follows:

Soil Fertility Investigations.

This project consists in an extended study of the effects of various methods of cropping upon the chemical, physical and bacterial nature of the soil, and upon the composition of the crops produced. This work is being carried on in connection with two series of rotation plots at the station, upon which different methods of cropping have been practiced since 1892 and 1895 respectively. This year a study is being made of the humus from these plots, and samples of all crops have been taken, and will be analyzed, to determine the exact amount of plant-food removed by each crop from each plot. All fertilizers placed on plots will also be analyzed. This is an Adams Fund project. Mr. G. W. Walker devotes all of his time to this work.

Fertilizer Experiments.

The purpose of these experiments is to determine the relative value of commercial fertilizers as compared with various crop rotations, and the use of farm manures in crop production, and the effect of long-continued use of such fertilizers upon the nature of the soil. Two sets of experiments have been started; one at this station, the other at the Northeast Sub-Station; and they will be continued over a period of years. A chemical study will be made of the soils and of the crops.

These experiments were started this year; but, on account of the drought, the results thus far are not satisfactory.

Special Soil Investigations.

A series of tests have been carried on for several years, in co-operation with farmers, to determine the value of commercial fertilizers on the various soil types of the state. This year fertilizer tests are being carried on at fourteen different places, with general farm and garden crops. Unfortunately, the severe drouth has prevented us from getting satisfactory results with most of the tests.

The purpose of this work has not been to encourage the use of such fertilizers, but to determine the plant-food needs of our soils, and the possible profit in the use of commercial fertilizers in general farm practice.

Soil Survey.

A large number of soils, including samples from practically all counties in the state, have been analyzed. However, in order to make our soil investigations of more immediate and practical value to the farmer, the following project has been undertaken: The station now has twenty-two demonstration farms and three sub-experiment stations, situated in various sections of the state, and including probably all soil types. An accurate soil survey is being made of each of these farms, which includes not only a determination of the exact soil types on each farm, but also the actual amount of plant-food in each ten-acre tract. On the basis of this survey, such experiments as seem advisable will be conducted, in order to determine how the productivity of the various types may be increased. A record will also be kept of the income and outgo of fertility from each farm. This work, when completed, should prove of great value to the farmers in the various sections of the state where these farms are located, and will give a basis for a more extended agricultural survey of the state.

Industrial Alcohol.

The legislature appropriated $6,000 for the establishment of an experimental industrial alcohol plant at the station. The contract has been let for the machinery and apparatus, and one of the present buildings on the grounds is being remodeled for the use of the alcohol plant. The plant will undoubtedly be completed and ready for operation by the end of this year.

In connection with this industrial alcohol problem, an exhaustive set of experiments was conducted during the past summer, to determine the relative lighting value of alcohol and kerosene. This work has been completed, and the results will be published at a later date, in connection with other reports on industrial alcohol.

Food Investigations.

Experiments are in progress to determine the changes taking place in cereals in the process of cooking, and to determine the relative economy in the use of gas or the fireless cooker, for cooking cereals.

Grain and Flour Investigations.

The legislature appropriated $1,000 for the purpose of establishing a grain- and flour-testing laboratory at this station. This laboratory has been installed in one of the rooms in the Chemical Building, and is now completely equipped for the testing of flour and grain. The equipment includes electric baking and drying ovens, sponge cases, and other necessary apparatus. In addition to this laboratory, we have a complete miniature flour-mill, so that we are now in a position to mill wheats, and to determine the baking value of the flour produced.

The purpose of this laboratory and mill is to enable us to co-operate with the wheat-breeders of this station, and others throughout the state, in determining the flour value of new varieties of wheat; with the State Board of Grain Inspection, and millers, in determining the flour value of commercial grades of wheat; and to enable us to help promote the growing of good milling wheats in this state.

Co-Operative Oat-Breeding Experiment.

This Division is co-operating with the Agricultural Division in an attempt to increase the protein content of oats. This experiment requires the determination, each year, of the nitrogen in a large number of samples of oats.

Work Done and Proposed.

In addition to the above-outlined work, a considerable amount of routine analytical work has been done for farmers throughout the state, and for other divisions of this station.

The work for the next year will be principally in connection with the projects outlined; but it cannot be carried on in a comprehensive manner without additional funds and assistants. With increased instruction work in the College and School of Agriculture, the need becomes imperative of assistants who may devote their entire time to station work.

Assistants Required.

An additional assistant, who may devote his entire time to analytical soil work, is needed. If the present annual legislative appropriation of $1,000, for special soil investigations,

could be increased to $2,500, it would provide for this assistant, and also for the various expenses in connection with the soil survey and other practical soil investigations throughout the state.

In connection with the industrial alcohol plant, it is practically impossible, with our present force, to attempt to conduct investigations bearing on the manufacture of alcohol from our various farm products. Sufficient funds, say at least $2,500 per year, should be provided for the operation of this plant, to cover salary of a trained assistant, who can operate the plant, and devote his whole time to the work. That amount would also take care of other necessary expenses. The legislature has provided this valuable experimental plant, and it would be a serious mistake not to provide funds to carry on the investigations.

The flour and wheat work should prove of great practical value to the farmers, millers and flour-consumers of the state. It is the aim of this work to determine the bread-making value of flour from all known types and varieties of wheat grown in this state, and to assist in promoting the growing of those varieties of wheat which will produce the best flour.

Laboratory of Agricultural Bacteriology Needed.

In this connection attention should be called to the need for a laboratory of agricultural bacteriology. Bacteria are responsible for most of the important changes in organic matter affecting the soil fertility. The study of their action is therefore of the first importance. They must also be studied with yeasts in fermentation changes in silage, denatured alcohol production, dairying, etc.

DIVISION OF BOTANY AND PLANT PATHOLOGY.

The fundamental work of the Disease Survey, as carried on previously in co-operation with the United States Department of Agriculture, has been continued. In connection with this, a survey of the weeds of Minnesota has also been carried on.

Pathology.

In the pathological experimental work, numerous experiments on the smuts of cereals have been carried on, and some of them completed. These deal chiefly with the loose smuts of wheat and barley, but fundamental work has been begun on the smut of corn. The main efforts in the pathological work have been directed towards the rusts of cereals, under which an Adams Fund project is pursued. The experimental field rust-plot has been enlarged and developed, and a system of rotation planned. The number of hybrids grown has increased considerably, and some results in the rust resistance of varieties have been obtained this year. On account of the fact that the season was exceptionally dry, rust was not prevalent, or even common, in the fields of the Northwest; so that the season gave excellent opportunity to try out the possibility of the rust epidemic, even under adverse conditions. A fairly vigorous epidemic of rust was obtained in the plot, and the results indicate what further improvements can almost certainly be made to insure an epidemic every year. Various physiological experiments on the rusts of cereals have also been carried on. An experimental field for the development of flax wilt and flax rust has also been established, and wilt has been introduced on this land. An epidemic of flax rust has also been obtained. This will give a basis for further work on flax.

The spraying work on fruit diseases was largely discontinued, on account of almost complete failure of the crop in the experimental orchards. A small orchard of the common varieties of apples and plums, and of the small fruits, has been established in the disease plot, where inoculation experiments may be carried on without danger of injury to the larger orchards. Some results were obtained on the spraying experiments, in connection with the burning of foliage by Bordeaux mixture. Work has been begun on the crown gall, with the view of determining the relationship of the crown gall of apples, which is very wide-spread throughout the state, to the crown gall of raspberries, and especially the possibility of infection of the latter from the former. The work is being planned toward the solution of the practical handling of the crown gall under existing conditions.

Several diseases of potatoes, particularly the early blight and internal brown rot, have been investigated, and a foundation laid for more extensive experiments. Work has been begun on a serious fruit-rot of tomatoes, which was prevalent the past year. Extensive experimental work has been carried on for the investigation of aster blight, but as yet with only negative results. Experiments in the damping-off of coniferous seedlings, in regard to various treatments, have given some results, which will allow of more extensive experiments in the future. An apparently new cucumber disease, which was very prevalent in 1908 and 1909, has been given considerable attention and space. The disease, however, was not common the past year.

Agricultural Botany.

Considerable work in the identification of weeds, for farmers throughout the state, has been carried on, and progress is being made towards a survey of the weeds of the state. Exhibition and demonstration material, aiming towards assisting the farmers to recognize weeds, has been prepared.

Special attention has been given to the development of the Seed Laboratory. Apparatus similar to that used in the United States Department of Agriculture Seed Laboratory has been installed, and a large collection of seeds for comparison has been made. About 800 seed tests have been made, and this department of the work has proved especially useful to the farmers of the state.

A seed-case, very convenient in size and very inexpensive, has been prepared for sale to the farmers, to enable them to recognize the seeds of the most common and dangerous weeds of the state. A large amount of material for the preparation of additional seed-cases has been prepared, and a new issue of these is planned.

Bulletins.

A scientific bulletin on the Rust of Cereals, prepared in co-operation with the United States Department of Agriculture, is ready for the press. A scientific bulletin on Sorghum Smut, also planned in co-operation with the United States Department, is nearly completed. A Station farmers' bulletin

on Smut has been prepared and is almost completed. A bulletin on Weeds, to assist the farmers in identification, and another on Seeds and Seed-Testing, are in preparation.

DIVISION OF AGRICULTURAL ENGINEERING.

On August 1, 1909, the Division of Agricultural Engineering was increased by combining with it the Division of Farm Structures and Farm Mechanics. The combination was due to the resignation of Professor Wm. Boss, who had been in charge of the latter Division.

During the year, investigations mentioned in the last report, which were being made to determine the best instruments for use in farm surveys, have been continued.

A study of the development of peat and muck lands for agricultural purposes has been begun.

The Division supervised the drainage of an eighty-acre demonstration farm at Belle Plaine, and installed a small tile-drainage experiment on heavy clay lands, at Meadowlands.

In order to determine the feasibility of wells as a method of disposing of underdrainage water, a tile-drainage experiment, with a well outlet, has been installed on the Experiment Farm in St. Paul.

The construction of the drainage system on the Northeast Experiment Farm has been begun, and will be completed in the near future.

As in the previous year, considerable time has been devoted to correspondence in regard to drainage and other agricultural engineering problems, with persons interested, in various parts of the state.

VETERINARY DIVISION.

The Veterinary Division has done a large amount of helpful correspondence with stock owners, and has had the veterinary care of our University Farm stock, in addition to its regular college and station work.

In Experiment Station work the Veterinary Division has had four projects under way:

(a) Anti-hog cholera vaccine work; which includes the production, introduction and distribution of an efficient vaccine; more economical production and lessened cost to stock-owners; a comparative study of the different methods of vaccination, and of conditions involving the potency and keeping qualities of the vaccine.

During the coming year the first work will be the continued production and distribution of serum to meet the needs of stock owners. Special attention will be given to methods of cheaper production; to preserving virulent blood without destroying its virulence; to conditions which affect the potency of finished serum; and to a living virus vaccine.

(b) Anti-tuberculosis vaccine. This has been a study of the practical value of von Behring's anti-tuberculosis vaccine, when used under ordinary farm conditions. In this work, the effect of vaccine upon the health of treated calves, duration of immunity, and degree of immunity, have been the problems held in view.

For the coming year, the work will be confined to observations on experimental calves, including tuberculin tests at the completion of the experiment which terminates during the coming year.

(c) Stable ventilation work has been under way for several years. This is confined largely to physiology research work with confined animals. Much new and important practical information has been secured. Some of this information is distinctly contrary to previous common belief and teaching. In this work the following points have been studied:

(1) Whether the animal body is actually injured by imperfect ventilation as found in ordinary stables.

(2) If the animal body is injured; then where and how?

(3) Least ventilation compatible with normal health, comfort and profitable feeding. This latter point is deemed of especial importance, on account of our long cold winters and the difficulty of efficient ventilation.

During the coming year, the most prominent features under this project will be: Disease-resistance in cattle, as affected by close confinement in unventilated stables, and the study of tissue metabolism, as represented by changes in blood and urine. We will endeavor to confirm or disprove unexpected results obtained in last year's work, particularly with reference to abnormal albumen in the urine, and nephritis, as indicated by blood in the urine of one of last year's experimental steers.

(d) Swamp Fever investigations. This is work with a new and serious disease of horses, concerning which very little had hitherto been known. This research has to do with the location of the virus in the diseased body, nature of the virus, natural methods of infection, and methods of prevention or treatment.

In this study it has been shown that the infection is due to a living virus so small as to be invisible under the microscope, and capable of passing through ordinary germ filters. It has been shown that swamp fever is not due to intestinal parasites, as held by some authorities; that the disease is probably not transmitted by ordinary exposure; and that infection may more probably be caused by biting insects.

During the coming year emphasis will be placed upon a continued study of the natural methods of infection, characteristics of the virus, and new work in connection with treatment.

NORTHWEST EXPERIMENT FARM.

The season of 1910 was a very dry one. However, the soil that has been tilled properly has yielded fair returns. No results were noticed from the tile drainage system. The observation-wells were cleared out and repaired, but no data regarding them was kept during the summer, as the wells were dry most of the time. It is planned to make a complete examination of the drainage system this fall, with the idea of learning what the effects have been of moisture and frost, and what effect, if any, the soil here may have on tile drainage. Most of the work has been completed on the surface drainage

ditches on the northeast quarter section of the farm, and the large drainage ditch is being cleared out at the present time.

In the spring, seven half-acre plots were laid out, and the following grasses and clovers were sown: Mammoth, red, medium red and alsike clover, timothy, red top, bromus and orchard grass. This season all these grasses and clovers failed to grow. Half-acre plots were laid out, and two courses of rotation started; one a seven-year rotation and the other a five-year rotation. For the seven-year rotation the following crops were selected: Wheat, barley, grass, grass, wheat, oats, corn; and for the five-year rotation: Wheat, grass, grass, oats, corn. A half-acre plot was laid out to be sown to grain continuously, and one for corn continuously.

Two acres of mangel-wurzels were sown and will yield a fair crop. Four acres of potatoes were planted; but, as a result of the dry weather, the yield was small. Three varieties of corn were planted, but all were frosted before they were mature. Twenty acres of corn were planted for ensilage, and produced 115 tons of ensilage. Another twenty acres was seeded to corn, late in the spring, but no crop resulted. About fifteen acres were sown to millet, late in the spring, but this failed also, on account of the dry season. Twenty acres of spring plowing were sown to barley, which produced good pasture for the sheep. Twenty acres of spring plowing were sown to flax, which was killed by the frost this fall. Twenty acres of prairie were broken up during the summer. This would have been impossible except for the fact that a gasoline tractor company loaned us the use of a machine. On account of the great amount of plowing, which ought to be done here at the right time, such a machine is an absolute necessity for this station.

On account of shortage of pasture, the cattle were turned out on a 110-acre field of prairie grass, which had in years past been cut for hay. Twenty-five acres of wild-hay land was cut over, but the yield was very light. Fifty-five acres of clover and timothy hay-land was cut over for hay, producing twenty-eight tons of hay. Five varieties of alfalfa have been sown here, namely, the Grimm, Dryland, French, Montana and Utah; and of these the Grimm produced the largest yield, which was at the rate of two tons per acre.

Eighty-five acres of oats were sown, but a part of these were cut for hay. The grasshoppers did some damage to the oats by cutting off the heads. The varieties of oats grown were: Minnesota No. 230; Minnesota No. 261; Minnesota No. 281, and Regenerated Swedish Select. Of these, the Swedish oats produced the best yield, giving thirty bushels per acre. Twenty-two acres of Minnesota No. 169 wheat was grown. The best yield of wheat was sixteen and a half bushels per acre. Three varieties of field-peas were sown, with the intention of harvesting them for seed, but they were all cut for hay. Twenty acres of No. 2 rye produced a yield of twelve bushels per acre.

The total field crops harvested at the present time are as follows:

Hay	35 tons
Ensilage	15 tons.
Oats	725 bushels.
Wheat	265 bushels.
Rye	224 bushels.

In stock, at the Northwest Experiment Farm, Short Horn and Holstein cattle are being raised. These breeds seem well adapted to this locality. A number of animals have been sold for breeding purposes, and there seems to be a general awakening among farmers regarding the value of breeding-up the herds. The gross receipts from the dairy cows was over $1,300. Returns from the sales of live stock amounted to nearly $1,000.

In hogs, the large Yorkshire and the Duroc Jersey are kept. This station has also the grade Shropshire sheep. The flock of sheep is as yet rather small, but is doing well. The White Leghorn and the Barred Plymouth Rock fowls are the main breeds of poultry kept. The poultry is doing very well. Something like 2,500 chicks were hatched during the summer, and a great many were sold. The gross receipts of this department were about $1,300. Toulouse and African geese and Pekin ducks are also bred. Minnesota Experiment Station Bulletin No. 119, giving the results of poultry experiments at the Northwest Experiment Farm, was issued during the past summer. It contains a full account of numerous experiments which have been conducted at this Station, and

is made a part of this report. The results of several years' investigation of the varieties of chickens bred here are favorable.

There were set out this spring one hundred fruit-trees, consisting of the following varieties: Duchess, Hibernel, Patten's Greening, Okabena, Wealthy, Florena and Whitney apples; Surprise and Forest Garden plums and Compass cherry. Four thousand White and Golden willow cuttings were set out north of the poultry yards, but most of them failed to grow. Two new buildings have been erected for the Crookston School of Agriculture,—one a girls' dormitory and the other an administration building. On the farm a pumping plant and water tank and a root cellar have been built, and a slaughter and a hog pen are now under construction. The grounds around the buildings have been graded, and an attempt has been made to sow grass-seed around them; but, on account of the dry season, the seed did not catch, and the work of seeding must be done again next spring.

NORTHEAST EXPERIMENT STATION.

The season of 1909 was generally favorable; though a drought in the first part of the growing season considerably shortened the yield of hay (first cutting) and early sown grain. Second-crop clover, late oats, fodder corn and potatoes gave heavy yields.

The grain crops, grown under field conditions, were wheat, oats, barley, peas, winter rye and a small field of No. 23 corn. The yield, as in past years (with the exception of corn), shows that the soil and climatic conditions of Northeastern Minnesota are as favorable to the production of grain as the grain-growing sections of the state. Corn, as far north as Grand Rapids, is not sure of maturing as a grain crop, though for fodder it yields with certainty and in great abundance. Minnesota No. 23, a small White Dent variety, promises to mature sufficiently early for a safe field crop. Minnesota No. 13 gives best results for fodder-corn. Kershon, an early variety of oats, was tried, in comparison with Improved Ligowa. This oats

(Kershon) showed great quality in resistance to drought, but was out-yielded by the later-maturing varieties (Improved Ligowa and Swedish Select) that derived benefit from the late rains. An English variety of oats, being tried at the Experiment Farm, gives great promise of value, especially in strength of straw (not lodging). The yield and quality of the grain is also high.

Records of the past two years indicate that field peas, on a sandy soil, are less profitable in a dry season than other grain crops. Potatoes, stock roots and vegetables gave their usual high yields; the soil and climatic conditions of northeastern Minnesota being especially favorable to the growth of these crops. In the growing of potatoes and vegetables the farmer of few acres and small means has the best opportunity to get along.

The dairy herd, on the Experiment Farm, has been developed to thirty milch cows and forty heifers. The sales from the herd, during the year, amounted to $2,370, aside from what was used on the farm. In the handling of the dairy herd, the aim is to make the work demonstrative of what the average farmer may do, dairying being the industry that is most profitable and best adapted to the natural conditions of northeastern Minnesota.

The foundation of the herd, on the Experiment Farm, is common stock of the dairy type. The young cows and heifers are the cross of a pure-bred Guernsey sire with the common stock cow. The heifers of this cross, now in milk, show a marked improvement in dairy production.

Pigs are raised in connection with the dairy, to utilize the skim-milk. The breed raised is the Large Improved Yorkshire—a bacon breed. The sows are bred to farrow in the spring (April). The young pigs are raised largely on clover pasture and skim-milk; fattened in the fall on barley, peas and roots; and put on the market by Nov. 1st. Under this system they are made to attain an average weight of about two hundred pounds.

Apple trees, planted on a sandy soil, have continuously winter-killed. In the spring of 1910 a new location was selected for the orchard, some distance from the grounds, but having a heavy clay soil. One hundred and fifty trees were

set out, and their growth and apparent vigor has been much more marked than when set on the sandy soil. The plum orchard (on sandy soil) has continued to yield well, and gave an exceptionally heavy crop in 1909.

The clearing of land has been taken up on the Experiment Farm, and the cheapest and most practical method of removing stumps is being determined. In this work, the Northeast Experiment Farm has co-operated with the Wisconsin Experiment Station and the United States Department of Agriculture. An expert investigator has been employed, who has now been in the field a part of two years; and his report is now in way of publication.

The work conducted on the Experiment Farm, thus far, seems to favor the use of dynamite as being the quickest, easiest and most economical method of removing stumps, when dynamite can be secured at wholesale prices. It has also been found, on the Experiment Farm, that the lower grades of dynamite, twenty-seven and thirty per cent, are equally efficient in removing stumps (except on very light soil) with the forty and sixty per cent grades, and are considerably cheaper.

Work is begun on the Northeast Experiment Farm on a complete system of tile drainage. The most important feature of this work will be the drainage of a muskeg swamp, to determine the value of this particular kind of swamp land, of which there are several hundred thousand acres in northeastern Minnesota.

The Experiment Farm aims to assist the pioneer farmers of northeastern Minnesota; and toward this end considerable time is given to farmers' meetings, in the promotion of co-operative creameries, dairy stock breeding associations and associations for marketing the products of the small farms. The development of agriculture in northeastern Minnesota is under most encouraging progress, and there is every assurance that the millions of acres of cut-over pine lands, now unoccupied, will in the near future be profitably farmed.

MORRIS SCHOOL AND STATION.

A sub-station has been organized in connection with the new School of Agriculture established at Morris. The farm contains two hundred and ninety-two acres, well located for demonstration work and fairly well equipped with buildings and barns.

CHANGES IN PERSONNEL.

The Station lost a friend and advisor in the death of former Dean and Director Liggett, on August 29th, 1909. On account of ill-health, it had become necessary for Director Liggett to lay down the burden of the work some time before his death, but he retained a lively and helpful interest in it to the last. The great results accomplished during his long administration will be a lasting monument to his memory.

A similar loss was suffered in the death of Prof. Robertson, Superintendent of the Crookston Sub-station, who died January 11th, 1910. He accomplished a great work in developing the Crookston Station and School on a sound basis.

Dean Olsen having resigned as Dean and Director, on February 1st, 1910, the present incumbent was elected to take his place.

On May 1st, 1910, Mr. J. A. Vye, for many years Secretary of the Station, resigned to go into private business.

The death of Prof. S. B. Green, on July 11th, 1910, has already been referred to.

Two of the most competent assistants in chemistry, J. A. Hummel and A. D. Wilhoit, also resigned to accept other positions. R. M. West and G. W. Walker were appointed to fill the vacancies. Mr. L. B. Bassett, our farm superintendent, resigned from the Agricultural Division, and A. C. Arny and G. J. Baker were added to the force. H. J. Franklin, of the Division of Entomology, resigned, and Theo. D. Urbahns was appointed to take his place. Dr. John Spencer was appointed to take the place of Dr. C. A. Pyle, who resigned from the Veterinary Division. C. H. Matthews was added as assistant in poultry, Elvin Stakman as assistant in Botany, and D. P. Tierney as assistant in Forestry.

A. F. WOODS,
Director.