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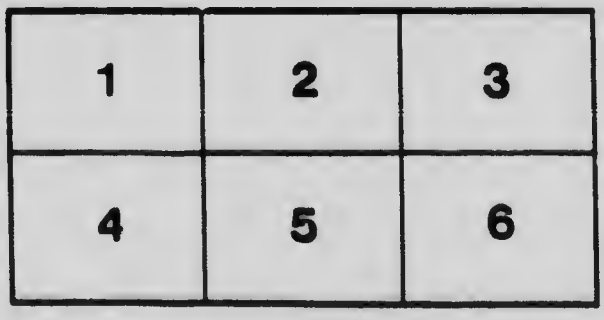

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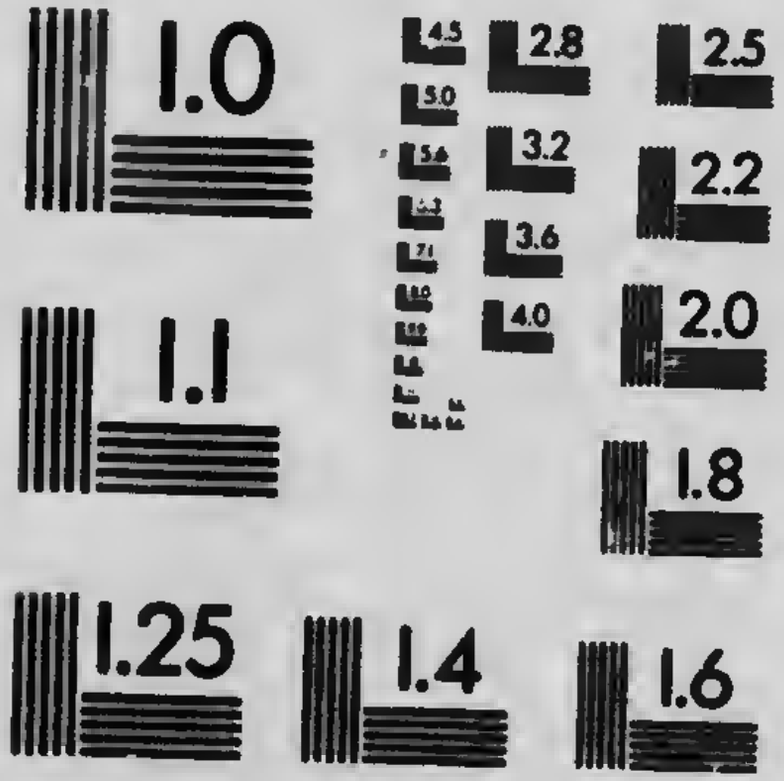

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The Work of the Dominion Experimental Farms

BY

FRANK T. SHUTT, M.A., F.I.C., F.R.S.C.
Assistant Director and Dominion Chemist.

From the Transactions of the Canadian Institute, Toronto.

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THE WORK OF THE DOMINION EXPERIMENTAL FARMS

BY FRANK T. SHUTT, M.A., F.I.C.

Assistant Director and Dominion Chemist.

Read 14th December, 1912.

Agriculture is the basic industry of Canada: it is the foundation upon which the Canada of to-day has been built and upon which she to-day rests. As it has been the pioneer occupation in this Dominion, so must it always remain the staple business of our people, influencing and determining by its development and progress the welfare and prosperity of our national life. To-day it employs directly more than half of our population.

Our commerce and our manufactures are directly or indirectly dependent for their expansion upon the country's harvests: as the latter increase in volume and value so will all other industries assume greater importance. In a word, Canada is essentially an agricultural, a food-producing country; as we are able to place more and more acres of our unoccupied lands under successful tillage, as we are able to profitably and without impairment of the fertility of our land increase crop yields, so shall we, in a very permanent and eminently satisfactory way, add to the nation's wealth, not only as regards agricultural products, but in the support and encouragement of every calling and occupation that makes for the country's good.

Another statement : Canada's cultivable land is her greatest and most valuable asset. And in saying this I am not unmindful of her many natural resources other than productive land, her mineral wealth, her immense forests, her large and valuable fisheries, her unsurpassed water-powers. All these as developed and properly conserved will indeed be ever-increasing sources of wealth, but nevertheless it will be the wealth and life as coming from our farms which will play the most important and vital part, which will contribute most towards the building up and prosperity of this country in its national life.

To support these contentions I may bring forward a few statistics regarding our tillable areas. In the nine provinces of Canada we have a land area of approximately 986,533,000 acres, of which at a very conservative estimate 36 per cent. (or 358,835,000 acres) is capable of occupation as farm lands. At the present time there is probably not more

than 8 per cent. of the total land area, or, say, 78,000,000 acres farmed or under settlement for agricultural purposes. Or, to consider the three western provinces only, Manitoba, Saskatchewan and Alberta, since it is towards them to-day the agricultural eyes of the world are more particularly directed, there are in this area, it is estimated, at from 170,000,000 to 200,000,000 acres suitable for cultivation, the greater part of which is adapted to wheat growing. Notwithstanding the rapid settlement of this vast land in recent years, probably not more than 8 per cent. is under tillage.

And it must not be supposed that the present provinces of Canada contain all our agricultural land. To the north and west of the Dominion lie the Territories of Mackenzie, Athabasca, and Yukon, and, leaving out of consideration the last named, it has been computed that there are at least 500,000,000 acres much of which may ultimately be capable of settlement. As yet we may be said to know very little as to the agricultural possibilities of this vast area, but this we can record, that wheat has been ripened at a number of points throughout it, as at Dunvegan and Fort Vermilion on the Peace River, the former 414 and the latter 591 miles north of the latitude of Winnipeg, and still farther north, as at Forts Providence and Simpson on the Mackenzie River, within 5 degrees of the Arctic Circle. Four years ago 30,000 bushels of wheat were harvested at Fort Vermilion, and there is satisfactory evidence that the Peace River country and much land even farther north will be found capable of producing wheat of excellent quality. Our northern limit for wheat growing is yet unknown.

And as to the value of our agricultural products as compared with the value of our other natural resources, let me say very briefly that according to the latest official statistics the total value for 1910 of farm products (field crops, live stock, fruits, poultry, dairy products, etc.) in Canada, consumed and exported, may be estimated in round numbers at $1,150,000,000, while for the fisheries we have for 1910-11 $29,965,433, for one year's cut (1909) from our forests $166,000,000, and for the mineral products (1911) $102,291,686.

If the foregoing has made good our contention as to the place of agriculture in Canada's development and prosperity, it is not to be wondered at that our governments, federal and provincial, should have shown such activity and generosity in recent years in providing means and establishing the necessary machinery for education in farming matters, for the solution of such agricultural problems as require scientific research and for giving assistance in such ways as may be practicable to the individual farmer in his everyday work. In the Dominion Experimental Farm system, the subject of my address to-night, we have the

chief means whereby the Federal Government has for more than two decades striven to assist and encourage Canadian agriculture.

In the year 1884 a Special Committee was appointed by the House of Commons to inquire into the causes for the depression that had for some years been experienced in Canadian agriculture and to suggest measures which might lead to a more prosperous condition of our farmers. This committee did its work thoroughly and well. In its report it was shown that farming methods, speaking generally, were primitive in character, irrational and wasteful, and that there was a widespread ignorance of those principles which must be observed if agriculture is to be placed and maintained on a permanent and profitable basis. Though there were some good farmers here and there throughout the country, who, by a judicious rotation of crops and the feeding of stock, kept up the fertility of their land, the rank and file were steadily impoverishing the soil, depleting it of plant food, by the sale of grain, hay, and potatoes, without any concomitant return as manure or fertiliser. And what was equally serious, as has been shown more particularly by our study of worn or partially exhausted soils, during the past twenty years, was the destruction of the humus or organic content of the soil following the irrational treatment of the land. We have come to regard humus as one of the soil's most important constituents, its loss not merely lowering the available food supply, but affecting disastrously those soil conditions, physical and biological, so desirable—nay, necessary—for the thrifty and vigorous growth of our farm crops. In a word, not only were crop yields going down, but for the most part the land under cultivation was markedly deteriorating.

After reviewing the condition of farming generally in Eastern Canada, for at that time the great North-West was scarcely entered upon, and asserting that the extremely unsatisfactory condition of our agriculture was largely due to haphazard and faulty methods, and certainly not the result of inherent deficiencies in our virgin soils or unfavourable climatic conditions, the Committee recommended as the chief remedial measure the establishment of Experimental Farms, which should be centres for experimentation and research in field and laboratory and the dissemination of information in all matters pertaining to agriculture, general and specialised. The report received the approval of the Government, and during the following session of Parliament, 1885-6, an Act was introduced and passed, almost unanimously, authorising the Dominion Government to establish a system comprising a Central Experimental Farm at Ottawa and four branch farms. The Hon. John Carling, then Minister of Agriculture, warmly favoured the proposed scheme, and lost no time in putting it into force. His first act was the appointment of

William Saunders, of London, Ontario, as Director of the system, this gentleman having already by special request examined into and reported upon agricultural experimental work in Europe and the United States. This choice proved a most fortunate one, for it is to the initiative, enthusiasm and the untiring energy of Dr. Saunders, who held the Directorship of the Experimental Farms from their establishment in 1886 till April, 1911, when he retired owing to ill health and advancing years, that the signal success of the system has been in a very large measure due. He had at the time of his appointment won recognition of a high order in the sciences of Chemistry and Botany and Entomology, and further, he brought to bear upon his work a very considerable experience in experimental agriculture and horticulture and in the art of landscape gardening. In the subsequent years he received many honours and distinctions from learned societies and universities at home and abroad, and for his invaluable work in promoting the interests of Canadian agriculture was in 1905 created by His Majesty, the late King Edward VII, a Companion of the Most Distinguished Order of Saint Michael and Saint George. Canada certainly owes a great debt of gratitude to Dr. Saunders for the splendid work he did for this country during the twenty-five years of his directorship of the Dominion Experimental Farms.

The five farms, the establishment of which was authorised in the Act of 1886, were all located and fairly well under way before the close of 1888. The sites for these were carefully chosen, not merely having in view readiness of access, as on a through line of railway, and, if possible, proximity to a large centre, but also the securing of land of a character representative of the district to be served.

The Central Farm, intended for the provinces of Ontario and Quebec, and to be the headquarters of the chief administrative officers and scientific staff of the system, was located at Ottawa. Here are the Chemical, Botanical and Entomological and other laboratories, fully equipped and with a force of trained men necessary to cope with the many problems requiring scientific investigation. The Farm, which is on the confines of the city, comprises in all some 465 acres. Of these about 100 acres are devoted to experimental work under the care of the Horticulturist, comprising 46 acres in fruits and vegetables, 21 acres in forest belt and tree plantations, and 33 acres in ornamental grounds and nurseries. From 25 to 30 acres are under the control of the Cerealist, for test plots and other investigatory work with the various grains. An Arboretum or Botanic Garden, under the care of the Botanist, occupies about 60 acres. The remainder, about 275 acres, furnishes the land necessary for carrying on the experiments in field and animal husbandry.

The four original branch farms were located as follows: Nappan, Nova

Scotia, for the Maritime Provinces; Brandon, Manitoba; Indian Head, Saskatchewan, for the area then comprising the North-West Territories; and at Agassiz, British Columbia, a point some 80 miles east of Vancouver, on the main line of the Canadian Pacific Railway. These, with the Central Farm, comprised the system until 1906, when the rapid settlement of Alberta seemed to demand points of investigation in that province. There was accordingly established in that year an Experimental Station for Southern Alberta at Lethbridge, for the purpose of studying problems in relation to the growth of crops under irrigation as well as those involved in agriculture under the so-called Dry Farming methods. In the year following (1907) a second Experimental Station for Alberta was established. This was located at Lacombe, about 115 miles north of Calgary, the climatic conditions and the nature of the soil in this part of Alberta being markedly different from those in the southern section of the province.

In 1908 an Experimental Station for Central Saskatchewan was located and equipped at Rosthern, within half a mile of the town of that name on the Canadian Northern Railway, and in 1910, a similar station for Northern Saskatchewan was established at Scott, on the line of the Grand Trunk Pacific Railway.

An Experimental Station for Prince Edward Island was established in 1909 at Charlottetown, occupying land on the outskirts of that city.

Still more recent (1911) are the two Experimental Stations placed in the Province of Quebec, the one at Cap Rouge, on the north shore of the St. Lawrence, near the city of Quebec, the other at Ste. Anne de la Pocatière, on the south shore, for the easterly portion of Quebec.

This year (1912) four more stations have been established, two in the East, at Kentville, Nova Scotia, and Fredericton, New Brunswick, and two in the West, at Sidney, on Vancouver Island, and the other at Invermere, on the Columbia River, British Colubmia.

The system, therefore, at the time of writing comprises sixteen farms and stations, four of which are in their first year of operation. The establishment of several more stations is now under consideration, to meet the urgent demand by new settlers for special investigation in hitherto unoccupied territory. The multiplication of stations is made necessary by the varying climatic conditions prevailing in different parts of the Dominion, for it must be borne in mind that climatic conditions, rather than character of the soil, form the most potent factor in determining the nature and the possibilities of agriculture in any particular district.

The branch farms and stations are in charge of superintendents

who are in constant communication with the Director and chief officers at the Central Farm, by whom the principal lines of investigation, with details of procedure, are laid down.

In addition to the foregoing, experimental work is carried on at a number of sub-stations, as at Fort Vermilion, on the Peace River, at Kamloops, and at Salmon Arm, British Columbia, and at Forts Smith, Resolution and Providence, towards the northerly limits of our agricultural areas.

It would not be possible in the course of this address to enter into any detailed account of the work of the chief officers at the Central Farm —the supervision and management of the whole system by the Director, the planning of experiments in field crops by the Field Husbandman, and with animals by the Animal Husbandman, the testing of varieties and the selection and breeding of new cereals and their distribution by the Cerealist, the improvement of our grasses and fodder crops by the Agrostologist—the investigatory work with all classes of fruits and vegetables, including the originating and propagation of good varieties suited to the climatic conditions prevailing in the different parts of our Dominion, and the study of forestry problems by the Horticulturist—the feeding and care of poultry for eggs and marketable birds by the Poultry Manager—the thousand and one problems requiring chemical investigation for their solution coming within the purview of the Chemist, with soils and the economic maintenance of their fertility, with manures and fertilisers, with fodder crops and all classes of stock foods, with spraying materials for the control of insect and fungus pests, with cultural methods for the conservation of soil moisture, with farm water supplies, and with a host of other questions, for the Chemist's work is intimately interwoven with that of all the divisions of agricultural research—the investigatory work of the Botanist and Bacteriologist, whose studies are more particularly with a view to the control and extermination of those vegetable organisms which if allowed to propagate, would do enormous damage in our orchards and to other farm crops, and, finally, the equally important work of the Entomologist, who has the administration of the Destructive Insect and Pest Act, and whose constant study and care is to prevent or control the ravages of those injurious insects which, if permitted to flourish, would disastrously affect our fruit and forest trees, our field and garden crops, our farm live stock and even man himself. For all this I must refer you to the twenty-six annual reports of the Experimental Farms and the numerous bulletins issued by the Farm during the past quarter of a century. Or if you wish a more succinct account I can refer you to a "Guide to the Experimental Farms and Stations", issued two months ago, which contains a very readable outline of our varied activities.

For our present purpose, therefore, I have selected from our work a number of examples that may be considered typical of the whole and illustrative of the results achieved in the various lines of investigation. They are merely indicative; many others might be cited equally or possibly more important to Canadian agriculture, if time permitted. And I must present them in the briefest possible language.

THE MAINTENANCE AND INCREASE OF SOIL FERTILITY.

This is a problem of fundamental importance, since a productive soil must be considered a *sine qua non* whether general farming or one of its specialised branches is to be pursued with profit. Our study of Canadian soils has shown many points of difference between those naturally poor and those naturally rich, between those which have been exhausted by irrational and wasteful methods and those farmed according to the dictates of common sense and the teachings of science.

The richest soils in Canada are the black loams of the great north-western plains, many of which have been shown to contain from 18,000 lbs. to 25,000 lbs. of nitrogen, from 4,000 lbs. to 6,000 lbs. of phosphoric acid, and from 10,000 lbs. to 15,000 lbs. of potash, per acre, calculated to a depth of 1 foot—amounts of these essential elements of plant food far in excess of those ordinarily found in soils of the best quality. This great fertility must, as far as possible, be conserved, maintained, if this national heritage, this valuable asset, is to be handed on as it ought to be, unimpaired for future generations.

Many of our poorest lands are to be found in the East—the districts first settled. These soils very probably never equalled in richness those of the prairie provinces, but irrational methods have gradually but surely impoverished them. Their fertility must be increased if farming in these districts is to be placed on a profitable basis.

What is the outstanding difference between these virgin soils of high fertility, of great productiveness, and those worn, exhausted soils? It is that the former are characterised by large percentages of semi-decomposed organic matter (humus) and nitrogen, whereas the latter show but meagre amounts of these constituents.

Further, we find, save in the semi-arid districts of the far West, that there is distinct relationship between the organic content and that of the nitrogen, that methods which destroy the former reduce the latter, and *vice versa*. The humus of the soil is Nature's storehouse for its reserve nitrogen, slowly made available for crop use through the agency of bacterial life under favourable soil and climatic conditions. The important functions of humus—physical, chemical and biological—are only begin-

ning to be realised by our farmers, indeed by agricultural chemists—and we might very easily devote a whole evening to their consideration. But time now forbids. As an outcome, however, of this investigatory work is one fact that must not lightly be passed over. It is that the percentage of nitrogen, under ordinary circumstances, is a direct index of a soil's fertility, that nitrogen is the most important, the dominant, the limiting factor determining crop production. In a very real sense it is true that a soil's fertility may be measured by its richness in nitrogen. In saying this I do not wish to be understood as minimising the importance of the other elements of plant food furnished by the soil, but rather as emphasising the unique place which soil nitrogen holds and the necessity for its up-keep. And we have also in this connection the comforting fact that in rational economic methods of enriching a soil in nitrogen we have the opportunity, constantly as it were, of keeping up a goodly supply of available phosphoric acid, potash and lime, and in preserving a favourable physical condition of the soil.

We must now pass on to consider briefly the methods that lead to the destruction of the humus and the dissipation of nitrogen, and on the other hand the means to be employed for the up-keep and increase of these constituents.

Their depletion, for instance, follows inevitably the practice of continuous grain growing, as commonly found, for example, to-day in the North-West, interspersed as it is with occasional summer fallowing for the purpose of conserving moisture and the eradication of weeds. Under such a system an investigation carried on at one of our Western Prairie Farms showed that in 22 years the soil lost to a depth of 8 inches more than 2,000 lbs. of nitrogen per acre, of which approximately 700 lbs. had been removed in the crops and the balance, 1,300 lbs., had been dissipated by the constant cultivation of the soil without any addition of humus-forming material. This soil is still an exceedingly rich one, and capable yet for many years of bearing maximum crops in favourable seasons, but chemistry tells the tale of impoverishment, and says that other methods must be adopted if the land is to be maintained in its high state of fertility.

We have areas in certain districts of the Maritime Provinces and Quebec once tilled and cropped, but now abandoned since they can no longer be profitably farmed. All taken, nothing put back. Their humus and nitrogen content have been largely dissipated, and this is undoubtedly the chief cause of their present unproductiveness. *Ex nihilo nihil fit.* Nature, in her slow but sure methods, is again restoring these worn-out, abandoned lands by covering them with vegetation, but soil building by

this process is extremely slow. The unwise farmer can do more harm to a soil in a decade than Nature can remedy possibly in centuries.

How, then, are soils to be maintained in a productive state and at the same time yield a profit for their working? First, in the keeping of live stock; in the manure so obtained we have the opportunity of restoring to the soil eight-tenths of the plant food taken from it in the crops they consume. In manures we have or ought to have the necessary and natural by-product of every farm. The farmer should recognise it as the home supply of plant food and humus-forming material—the chief means of holding and increasing the productiveness of his soils. This truth is not as yet fully realised by all our people. We do not keep sufficient live stock on our farms.

Many investigations have been conducted with manures, their right care and application, but we cannot now enter upon details. We have determined the tremendous losses in plant food, especially nitrogen, and in organic matter, that ensue by leaching and fermentation, when the manure is allowed to lie for months, as it frequently is, in loose heaps in the open barnyard. We have showed that while manure rotted under good conditions contains, weight for weight, more plant food than fresh manure, yet the losses in rotting may and very frequently do, outbalance the benefits. Our field and laboratory work alike prove that the safest storehouse for manure is the soil, and that the farmer who gets his manure while still fresh into the soil returns to it for the future use of his crops much more plant nourishment than he who allows the manure to accumulate in piles that receive little or no care, and which, therefore, must waste by excessive fermentation and leaching, or both.

Secondly, the land must be put under a proper rotation of crops. There are many reasons for this, chemical and physical. We have already learnt the disastrous effect on the soil's humus and nitrogen by continuous grain growing; the same would be true if we endeavoured to grow a hoed crop, as potatoes, for instance, year after year. The soil must be enriched by the sowing of a sod-forming, fibre-producing crop—in other words, the land must be occasionally laid down to grass. Much work has been done at almost all the Experimental Farms in testing out the merits and economy of different rotations, to meet the varying needs and conditions of agriculture as found in widely distant parts of the Dominion. As a lesson to be learnt from this work it may be stated that the Central Experimental Farm records furnish a number of examples of the good effects of proper cultural methods and right rotations upon the crop-producing powers of soils. As among the most striking might be cited the following:

In 1899 a system of crop rotation was introduced on that part of

the Central Farm devoted to general agriculture. At certain fixed prices for various products the value of the crop harvested that year was $2,776.66. Using the same prices as in 1899, the value of the crops off the same area in 1911 was $5,478.90, and will be considerably greater than this in 1912, all figures for which crops are not yet available. This shows the effect of good cultivation and right rotations on a given area.

As illustrative of the effects of such treatment upon the returns and profits possible from an acre of land the following figures are illuminating:

In 1910, according to the Census and Statistics Monthly, the crop value per acre throughout Canada was $15.50. The cost to produce this crop was about $9.60 per acre, therefore the net profit per acre was almost $6.00. On the Central Experimental Farm, using the same prices or values, the crop was worth $44.13 per acre produced at a cost of about $12.65 per acre. This leaves a net profit of $31.48 per acre for the Experimental Farm as compared with $6.00 for the average farmer or over five times as great a net profit. In 1911 the difference was quite as striking, while the returns for 1912 promise to be still more markedly in favour of the superior cultural methods which undoubtedly account for the difference. These and similar results are proving of the greatest value to the farmer of this country.

We may now proceed to say something of our investigatory work with legumes, Nature's soil enrichers, the only crop that leaves the soil with more nitrogen than it found in it.

The legumes constitute that great family to which the clovers, alfalfa, peas, beans and the like belong, and which alone of all farm crops are able to draw for their sustenance from that vast store of free nitrogen present in the atmosphere. This they are enabled to do—not of themselves, but through the agency of certain nitrogen-fixing bacteria in the soil and which attach themselves and reside in nodules or tubercles upon the roots of the legumes, passing on their elaborated nitrogen to their host for the building up of its tissues of root, stem, and leaf. The ancients knew of the value of clover as a soil enricher, but it was only in 1886 that Hellriegel and Wilfarth discovered the reason why. It was the agricultural discovery of the century, and the practical results following from it have proved of far-reaching importance and value.

For twenty-five years we have assiduously studied this question of the use of legumes as manurial agents in all its phases—in the field and orchard, in the experimental plot and in the laboratory—and we have also established their place as nutritive fodders of the highest rank. We have determined the amounts of nitrogen appropriated from the air and stored up in the roots, stem, and foliage of a large number of these

legumes. We have noted the increase of yield in crops succeeding them; we have ascertained the increase of soil nitrogen due to their growth, and we have investigated the merits of the various cultures put upon the market for inoculation of the soil with the nitrogen-fixing bacteria. The results of these researches would occupy several volumes, but I must try to condense them into two or three sentences.

Analyses have shown that from 75 to 150 lbs. of nitrogen may be stored up in a season, per acre, by the more common legumes. This is very largely from the atmosphere if the roots of the crop are nodule-bearing. The ploughing under of such a crop adds to the soil's store of reserve nitrogen, we may say, as much as would be furnished by an application of 10 tons of good barnyard manure. And this is but one of many advantages of this system of soil improvement. The plan of sowing clover with the cereal crops is now common in the older parts of the Dominion, and it is proving a very valuable one in the enrichment of our soils. The adoption of this method is, I believe, very largely due to the teachings of the Experimental Farms.

As regards increase in crop yields after clover, I may cite one of our many experiments. Series I comprised two adjacent plots, the one carrying clover the other carrying wheat. In the succeeding year both were planted with fodder corn; the crop from the clover plot exceeded that of the adjoining by 8 tons 480 lbs. per acre. In the following year both plots were sown with oats; the original clover plot gave 23 bus. 18 lbs. more per acre than its neighbour. Further, the third year after clover, both were planted with sugar beets; the yield from the plot that had borne the legume was 13 tons 1400 lbs. per acre more than that of the wheat plot. We invariably obtained an increased yield on the land that had carried the clover or other legume, for at least three years to a marked degree. Evidence of this practical nature is overwhelmingly convincing of the manurial value of the legumes.

In the determination by direct analysis of the soil of the amount of nitrogen that might become part and parcel of the soil through the continuous growth of clover, the results of one experiment may be cited. This plot of very poor sandy soil was first sown with clover in 1902, ten years ago, and has been continuously under that crop since that date. The soil was enriched at the outset with phosphoric acid and potash but no nitrogen was added. The nitrogen content was taken at the beginning of the experiment and every second year since. The net gain in organic nitrogen at the end of the ten-year period was approximately 500 lbs. in the first 4 inches of soil per acre. From other work we assume that the loss of nitrogen from various causes in such a light soil as that under experiment—almost a pure sand—must at least

equal the net gain, so that we may conclude the clover added to the soil in the neighbourhood of 100 lbs. per acre per annum.

And lastly, in this connection I have to speak of our work with bacterial cultures for inoculating the soil with those nitrogen-fixing organisms that permit the legume to draw upon the store of free nitrogen in the atmosphere. The details of this investigation are very voluminous, for the merits of many European, American and Canadian cultures have been tested in pots and, on a larger scale, in half-acre plots. It must suffice now to say that while some proved effective in promoting the growth of the legumes, many proved worthless, no doubt due largely to the susceptibility of the organisms in the cultures to light and heat. Their vitality becomes seriously impaired with the keeping of the preparation. Cultures, therefore, unless fresh cannot be depended upon, and experience has taught us that the best inoculating material for clover or alfalfa is the surface soil from a field that has recently grown clover or alfalfa.

About 300 lbs. of soil are required per acre, broadcasted and harrowed in. This is the surest and most direct method of inoculation. Such soil can be obtained from nearly all the Experimental Farms on payment of a small fee to cover the necessary freight charges.

Though it has been conclusively shown that there are districts in which inoculation is useful, it should be noted that inoculation is not generally necessary. The nitrogen-fixing bacteria are not restricted to a few small or isolated areas—our observations have proved that—and we have reason to believe that many failures with clover have been due to lack of moisture, poverty in humus, sourness or an unfavourable mechanical condition of the soil, rather than to absence of these valuable organisms.

Perhaps at this juncture I should say something of the use of the so-called chemical or commercial fertilisers. Have they a place in a rational, economic farming system? We believe they have, but it must be secondary to the means I have outlined for the up-keep of fertility. Fertilisers are no substitute for farm manures, though they can frequently be used profitably as supplemental to manures. They furnish plant food in available forms, but they do not add humus-forming material, so necessary to the formation of a comfortable habitat for plants and the retention of a due proportion of moisture. They are frequently a snare to the [illegible]r farmer who depends solely upon them, but they may be employed with great profit at times by one who conducts his operations on rational lines. The farmer who would use them with profit must keep up the organic content of his soil and be prepared to do some experimental work. In general farming they have not as yet

been largely employed, nor do we advise such use unless the farmer understands their character and properties; but the time is coming, especially in the older portions of the country, when they will be more extensively employed. Hitherto it has been the fruit grower or other specialist who has reaped the greatest benefit from them.

FIELD CROPS.

Experimental work with the ordinary farm crops has naturally received much attention. The influence of rotations and of drainage, the cultivation of the soil and its manuring, the preparation of a good seed bed, the effect of early and late seeding, the use of pure seed of strong vitality and many other factors in crop production have been carefully and thoroughly studied.

The testing of newly introduced varieties of all classes of crops has always been a strong feature. These include cereals, grasses and forage and farm crops generally. An annual bulletin on the subject informs the farmer as to the merits and yields of the different varieties and strains offered for sale by seedsmen. The plot and field work in many instances is supplemented by analysis, so that we have been able to place on record data as to the composition and nutritive values of many grasses, native and introduced, of varieties of Indian corn as grown for fodders and the silo, of different strains of mangels, carrots, turnips, etc., etc. We have also worked out the stage of growth at which Indian corn, certain grasses, clovers, etc., should be cut, so that the harvested material may be at its best, both as to composition and digestibility. The excellent quality of the sc[illegible]ured western prairie grasses has also been demonstrated.

SUGAR-BEETS FOR FACTORY PURPOSES.

The more important factory varieties of sugar-beets have been grown on the larger number of the Experimental Farms and Stations. Representative samples of these are submitted to analysis year by year, as to sugar content and purity. We have ample evidence that as regards these two important points very satisfactory sugar-beets can be grown in many parts of Canada.

CANADIAN CEREALS.

Red Fife wheat as grown in the Canadian North-West has earned for the Dominion the enviable reputation of being one of the finest wheat-producing countries in the world. The very high breadmaking qualities of the flour from Red Fife is admitted in all the markets of the world. There remained, however, an important field for experimenta-

tion in the production of earlier ripening varieties, better suited to northern areas of the Dominion, characterised by a short season. This problem of finding a spring wheat of the quality of Red Fife but which would ripen before there was danger of early autumnal frosts was entered upon in the early days of the Farm System and from that time until now many hundreds of new kinds have been produced by cross-breeding, using for this work chiefly Red Fife and early ripening sorts from India and Northern Russia. Among the new cross-bred varieties of very high productiveness and of early ripening habit are the Marquis, Preston and Huron, the first named being the most noteworthy. Marquis is now displacing the others (and also Red Fife) in many wheat areas of the North-West. It is about a week earlier in ripening than Red Fife, produces usually from 10% to 60% more crop (in Saskatchewan) and yields flour of the same character as Red Fife. It won the highest award this year and last year in international competitions open to the world for the best hard wheat.

Prelude, just being introduced, ripens about two weeks before Marquis and gives a good yield of very hard plump wheat. Its flour is of the highest rank for baking strength but has a slightly yellowish tinge. This wheat may prove of the greatest value in Northern Saskatchewan and other northern districts, in which specially early ripening sorts must be grown to escape frosts.

Concurrently with this research by the Cerealist and to supplement his results in the Baking laboratory, chemical and physical analyses have been made of many of the cross-bred wheats so obtained. The information so gained has proved of considerable assistance in discriminating between these new varieties.

In barleys more than a hundred cross-bred sorts are now being studied. A selected type of Manchurian has been introduced with excellent results.

A new cross-bred variety of peas, the Arthur, has proved the earliest of all-round yellow field peas and of unusual productiveness. It is now being actively introduced with very gratifying results in almost all sections of the country.

The annual distribution of seed grain is an important work also in charge of the Dominion Cerealist. Samples of new and improved varieties of wheat, oats and barley have, on application, been sent to farmers who will undertake to sow them according to instructions and report on the growth, yield obtained, etc. By this means information has been obtained as to the merits of different varieties under widely varying conditions of soil and climate, and much good achieved by the introduction and dissemination of the best sorts of grain.

Reference has already been made to investigations carried on conjointly by the Cereal Division and the Division of Chemistry, and as a further illustration of this class of work I may cite our search for a chemical basis for determining the breadmaking value of a flour, an analytical method that would give results in accord with those from direct baking trials. Our data on this matter are perhaps more voluminous than satisfactory, but nevertheless we have made some headway in determining "strength" of flour by chemical means. We have in certain very important particulars been able to correlate the baking and chemical results.

The influence of soil and climatic condition on the composition of wheat and barley has been carefully and systematically studied for a number of years by the Chemical Division. This research has thrown much light on the cause of the high quality of our northwestern-grown wheats. We have found that the amount of available soil moisture together with the temperature prevailing during the period in which the grain is filling are important factors in determining the character of the grain. A fairly dry soil accompanied by high maximum temperatures, such as we usually find over large areas over the North-West during later summer months, arrest vegetative growth of the plant, hasten maturity and conduce to a hard berry with a high percentage of gluten. On the other hand, grain grown with an abundance of moisture and conditions conducive to the lengthening the vegetative period will be starchy and "soft". The highest type of malting barley is one possessing a low percentage of protein, and such we may look for when grown under irrigation.

Among other investigations in which the Cereal and Chemical Divisions have collaborated may be mentioned, "The influence of artificial bleaching on the quality of flour" and "The influence of storage on the composition and breadmaking value of flour".

HORTICULTURAL WORK.

We must now pass on to speak of the experimental work in the field of horticulture, a very wide and varied field, and a work that has yielded most valuable results to the fruit-growing interests in all parts of the Dominion. Here, as all through this account of our investigations, I can only take a few examples which may illustrate the scope and character of the work.

And, first, in connection with apple growing, I would remind you of the classic work of Dr. William Saunders in his attempt to obtain an apple that would endure the rigorous winters of the prairie provinces. This was begun in 1894 by cross-fertilising the flowers of the extremely

hardy Pyrus baccata with pollen from many of the hardiest and best sorts of apples grown in Ontario. Many hundreds of such crosses were made, and later many hundreds of seedlings from the first generation were raised. Almost all of these proved perfectly hardy under the severe tests they were submitted to in the North-West, and their fruit, though small, was found admirable for jelly-making. Second crosses were made using cultivated varieties, and from these and other crosses trees have been grown that apparently are hardy and which have yielded fruit of fair size and in some cases of excellent quality.

Of the many lines of experimentation now being carried on in apple breeding and testing by the Dominion Horticulturist, the following may be cited: (1) The testing of varieties as to hardiness, prolificness, flavour of fruit, etc., when grown in widely distant points throughout the Dominion. (2) The testing of seedlings from seed of between 400 and 500 named varieties growing in our orchards at Ottawa. This means that only one parent of these seedlings is known, natural pollination having taken place from other trees in the orchard, many of which furnish apples of the best flavour and quality. Many of these seedlings have fruited and the results are surprisingly good. Over 70 per cent. have been found of marketable size and of good quality. (3) Cross-breeding experiments have been conducted for the past 12 years, more particularly with the view of obtaining hardy, vigorous trees producing an apple of good flavour and of long-keeping quality. Only a few of the trees so produced have as yet fruited, but the prospects of success are excellent. (4) Individualism in apple trees is being investigated. For 15 years the yields from the trees under experiment have been recorded, and as a result it has been noted that a marked variation as regards prolificness exists between trees of the same variety and age and grown under the same conditions. Some trees have yielded from two to four times as much as others. Scions have been taken from these heavier yielding trees and top grafted to learn if this individuality can be perpetuated.

In all sorts of small fruits and vegetables testing is carried on at Ottawa and on the branch farms. As a result we are in a position to advise as to the best varieties suitable for growth in the different parts of Canada.

Cover crops for orchards have long been under experiment, for protecting the roots of trees in winter and adding humus and plant food when ploughed under. For the most part these crops have been legumes or nitrogen-gatherers (clover, vetches, beans, etc.), but some others, such as rape and rye, have been included. The system of orchard management which comprises the use of cover crops with clean culture is now widely adopted; it appears to be the most economic and effective

method for the control of soil moisture, the up-keep of fertility and winter protection of the trees. In a large part of this work the Chemical Division has co-operated, so that the information gained might be as complete as possible.

We were, I believe, the first in Canada to advocate the spraying of orchards, and experimental work in connection with this practical and effective means of controlling insect and fungus pests has always been a prominent feature of our horticultural programme. Much advance has been made in the last twenty years in this matter, and the data obtained in the orchards of the Central Farm with Bordeaux mixture, various arsenites and arsenates, lime sulphides, etc., etc., have enabled us to advise our fruit growers respecting the value and use of the various manufactured and home-made fungicides and insecticides. In this inquiry chemical work as to the composition and preparation of sprays and spraying materials has gone hand in hand with the practical trials in the orchard and thus made the results more valuable.

ANIMAL HUSBANDRY.

Experiments in the breeding, feeding and care of live stock have been carried on at the Central and most of the branch farms. Many lines of work have been conducted with horses, cattle, sheep and swine. One or two examples may suffice to bring before you the character of this work and the value of the results.

Experiments in beef production have conclusively shown that as the animals more nearly approach a typically beef type, the greater the profit that may be expected. Scrub animals make poor use of their food.

The economy in feeding a liberal allowance of succulent roughage, e.g., corn ensilage and roots, has been demonstrated, and that among the coarse, dry fodders, clover and alfalfa hays have proved more nutritious than the more commonly used timothy hay.

All the more important concentrates, milling by-products, etc., have been tried in various proportions and well-balanced rations therefrom compounded.

The influence of age on the cost of making gains has been well worked out; the older the animal the more expensive the increase in live weight.

More profit is attached to the practice of feeding steers so that they may be ready for the block at an age of two years or less than to the plan of taking three or four years to bring them to a condition fit to kill.

Dehorned steers, fed in box stalls loose, say 8 or 10 together, do better than steers fed tied, on the same food.

With dairy cattle our experience has shown that as regards milk and butter production individuality is a very important factor. Admitting that we have breeds specially adapted to dairy purposes, e.g., Jersey Ayrshire, Holstein, etc., the best individual must be looked for among them rather than a comparison made between the breeds. This entails the constant testing of the milk and a daily record of yield. There is no best breed, all points considered.

The feeding of ensilage or other succulent fodder is essential to cheap milk production, especially in the winter season, and the hays of clover and alfalfa may be used with profit to reduce the meal portion of the ration.

The practice of "soiling" or feeding green forage allows a larger number of cows to be maintained on a given area than if the land is pastured, and is to be considered as essential to intensive dairying. Many "soiling" crops (e.g., peas, oats, rye, corn and clover) have been tried and reported on with special reference to their value for supplementing the pasture during times of drought and as the season advances.

While the total quantities of milk and butter fat in a given period may be influenced by the feeding, it does not appear that the percentage of fat is appreciably affected by the character of the feed.

In the breeding and feeding of swine several thousands of animals have been used. The stock experimented with for the most part has consisted of Yorkshire, Berkshire and Tamworths. Among the more important lines of investigation might be mentioned the breeding of animals specially suited for the production of export bacon. The importance of this work is obvious when we remember the very large proportions to which our trade with England in this commodity has grown.

And in this connection I may briefly refer to an exhaustive examination into the character and causes of "Soft Pork" undertaken by the Division of Chemistry—an investigation that lasted three years and in which more than 300 pigs were put under test. We were able to establish by chemical analysis that certain rations, and especially those containing a large proportion of Indian corn, produced an undesirable bacon by reason of the high percentage of olein in its fat. And among other important findings we learnt that there was no better corrective to this undesirable quality of softness than the by-product skim milk, the addition of which to the grain ration tended also to thriftiness and rapid growth.

The summer and winter housing of swine and the profitable use of summer pastures and green succulent crops for growing pigs, are among the numerous other matters relating to the swine industry that have been investigated.

Special attention has been given, more particularly in recent years, to the best construction of buildings for the housing of all classes of farm stock, having in view efficient lighting and ventilation, factors of the highest import to the health and thrift of the animals.

EXPERIMENTAL WORK IN POULTRY.

The poultry industry in Canada has of late years rapidly advanced, and to supply the information and advice asked for by the ever-increasing number of poultry keepers, much experimental work has been undertaken. This has been chiefly conducted at the Central Farm.

This work has naturally fallen largely into two lines: The breeding, feeding and care for egg production and the breeding and feeding for first-class table fowl, and many valuable data have accumulated in the course of years in both branches. In a very condensed form I may present some of the more important results:

1. Variety in rations is essential to good egg production, and especially so during the winter season. The value of freshly crushed green bone, meat meal or other good animal food, as well as a certain proportion of green stuff, in addition to the mixed grain feed, has been established.

2. In egg production, individuals differ widely and our results have shown the wisdom of systematic breeding from hens of known laying capacity.

3. For properly fattened fowl birds of the right type should be used. They may be fattened in coops, and crushed, sifted oats with barley meal and fine shorts mixed with skim milk has been found a preferable ration and one that has given birds of the highest market value.

Here as with other classes of live stock, proper housing has been a subject of experiment, and the so-called "cotton-front house" has been found conducive both to the health of the birds and a good egg production.

BOTANICAL WORK.

No institution of agricultural research would be complete without a scientific staff and properly equipped laboratories for the study of those parasitic organisms to which are due so many diseases that attack our economic plants. It would appear that as the area under cultiva-

tion increases, as cultural methods become more intensive, and "improved" varieties of crops are employed, the "improvement" of which consists chiefly in the power of returning under favourable conditions a larger yield, without reference to their power of disease resistance, serious diseases become more frequent in their occurrence and more destructive in their effects, unless special measures are taken to safeguard crops against them. Hence there is much work for the plant pathologist who, by microscopic examination and cultural methods in the laboratory and experiments in the greenhouse or field, isolates the organisms which produce the diseases, studies their life history, determines experimentally the conditions under which they become destructive and the measures which may be successfully undertaken for their control. Fungus diseases do much harm to orchard and field crops, reducing yields and lowering the value of such produce as may be obtained. Not infrequently the loss from a single disease of one particular crop may in a season favourable to the disease amount to thousands of dollars, as, for instance, in the case of Fire Blight of apple and pear trees, or smut of wheat, or Late Blight of potatoes. These diseases cannot be ignored. It is doubtful if there is a single crop immune from their attack and, generally speaking, the more important the crop the greater the number of diseases to which it is subject. It is, therefore, the duty of the Botanist to carry on inquiries and investigations respecting the control of the diseases which appear to most seriously interfere with the work of the agriculturist and horticulturist in this country; to keep himself informed of what is being done along similar lines at other centres of investigation; and to utilise the results of his own work and those of his co-workers to furnish to the perplexed cultivator the best information available on the subject. Among the diseases more particularly under investigation at present are the Silver Leaf of fruit trees, Black Rot of cherry and plum, Scab, "Rhizoctonia" and other diseases of potatoes and Smut diseases of grain.

The difficult problem of working out methods for the control and eradication of noxious weeds and poisonous plants is another and important feature of the Botanist's work.

The Botanist also has charge of the Arboretum at the Central Farm in which there is to be found an extensive collection of hardy trees, shrubs and perennials, the result of many years' experimentation with plants from many distant parts of the world. In addition, an effort is being made to gradually bring together a collection of native plants which shall comprise all representatives of the Canadian Flora hardy enough to be grown at the Farm without special protection, to-

gether with such other plants as from their importance in the arts, industries or medicine are of special interest. This Arboretum or Botanic Garden occupies 60 acres in a commanding position, and contributes not only a very pleasant park, but a place of great educational value to the lover of trees and plants.

ENTOMOLOGICAL WORK.

As in the case of the Botanist, the Entomologist's chief work is towards the protection of trees and fruits and crops generally against the ravages of pests, but here we have to do with injurious insects that attack and destroy, and which, if left unchecked, would soon make our agriculture profitless. As already intimated, the work of the Entomologist includes the study of insects affecting live stock, such as the horn-fly, ticks, mites, etc. Apiculture and the production of honey also comes within the scope of this study.

The study of the life history of injurious and beneficial insects carried on in laboratory, insectary, field and forest, is essential as a first step towards the formulating of effective and practicable methods for their control or destruction. It is a work, therefore, of primary importance, and consequently one to which much close attention has been given.

More recently among the many methods of control is that of keeping in check the development and spread of injurious insects by the introduction and distribution of parasitic insects. These natural means of control, as they may be called, bear much promise, and the Dominion Entomologist has already met with some success in this comparatively new sphere of work, and there is great hope that he may still be more successful in stamping out, or at all events in preventing the spread of certain insects otherwise uncontrollable.

For the purpose of introducing, studying and establishing the natural parasitic enemies of insect pests in localities in which the latter are prevalent, a most important development of the entomological work has been recently made in the equipment of field entomological laboratories in different parts of Canada. Six such entomological stations were established during the past year, and even in the first year of their history important results have been obtained. One of the most interesting of these is the introduction, establishment and proven spread in New Brunswick of an important European parasite of that dangerous pest, the Brown Tail Moth. In Nova Scotia, Quebec, Ontario and British Columbia valuable and encouraging results have already been obtained in the laboratories established in these provinces.

The Entomologist has also the administration of the "Destructive Insect and Pest Act", passed in 1910, to prevent the introduction into Canada and spreading of insects and other pests injurious to vegetation. Under the regulations of this Act, trees, shrubs and nursery stock may only be imported into Canada during certain specified periods of the year and through certain ports, of which there are nine in the Dominion. At six of these ports fumigation stations have been established where certain classes of trees and plants are fumigated with hydrocyanic acid to prevent the introduction of San José and other scale insects.

Plants from certain countries are inspected either at the port of entry or at their destination. The protective value of this inspection work has been frequently demonstrated by the discovery of such serious pests as the Gipsy and Brown Tail Moths and certain scale insects on imported trees.

Many other aspects of the Entomologist's work of controlling and eradicating the countless insect pests affecting man in all his activities and his pursuits might be referred to, but space will not permit. I would, however, mention the important investigations that have been made in recent years by the Entomologist at Ottawa, respecting the ubiquitous house-fly, its menace to health and the means for its suppression.

CHEMICAL WORK.

And lastly I come to speak of the work of the Division of Chemistry. Of its fundamental and varied character you will have judged from the many references made in this address to the aid that chemical research has given towards the solution of the numerous problems in general and specialised farming. The relationship that exists between modern and progressive agriculture and chemistry is a very important and intimate one, so that we may say with a very large measure of truth that up-to-date farming is putting into practice the teachings of agricultural chemistry. The requirements of crops and animals, the constitution and needs of soils, the most economical means of maintaining and increasing soil fertility, the nature and amounts of fertilizing ingredients in manures, the relative nutritive value of forage crops and cattle foods, the composition of dairy products, the constitution and preparation of fungicides and insecticides, all these and many more form the subjects of chemical research and analysis. I shall but indicate some of the more important of these investigations now in progress, omitting mention of those already alluded to in the course of this address.

Canadian Soils.

The chemical and physical examination of virgin soils and those from unoccupied areas has always been a matter of particular interest

to us. The value of the data so obtained will be apparent, not only for the present but for the future successful farming of these lands. Soil analysis is a tedious affair, but we have during the course of years put on record the data of many types of soils found in the Dominion. Two years ago we were able to issue an important bulletin on the Western prairie soils, which has received wide recognition. This work continues, and our labours in this connection have been extended in recent years to typical soils from Nova Scotia and New Brunswick in the East and British Columbia in the West. We have found the knowledge so gained of much assistance in advising our farmers respecting the economic up-keep of these lands and in the use of manures and fertilisers.

Conservation of Soil Moisture.

In districts of sparse rainfall, as in certain parts of North-Western Canada, in which, unless there be provision for irrigation, the so-called "dry-farming" methods must be practised, the question of the absorption and retention of moisture by the soil is all-important. The principles of moisture conservation are fairly well and widely understood, but there yet remain many features in the economical working of the soil to be satisfactorily settled. The value of sub-soiling, the depth and time of ploughing, the frequency, nature and depth of surface cultivation, the value and kind of sub-surface packing are all points requiring investigation on both heavy and light soils. In the autumn of 1910, therefore, an exhaustive series of experiments in soil culture was planned by the Agriculturist and Chemist, to be carried out at a number of the Western Experimental Farms, to learn the effect of various cultural treatments on crop yields and with the hope that these yields might be correlated with the moisture content of the soils. To this end determinations of the moisture in samples taken to several depths from the experimental plots at regular intervals throughout the season have been made. The results indicate the influence of the several cultural methods under examination on the moisture content of the soil to a depth of 5 feet. Several hundreds of such samples have been examined monthly during the past two seasons. We find that the moisture content of the soil may be profoundly modified by the nature and time of treatment employed, and several facts of considerable practical importance in the working of the land, looking to a greater conservation of moisture, have been brought out.

The Fertilising Value of Rain and Snow.

The nitrogen compounds present in the rain and snow as falling at Ottawa have been determined since 1906. This investigation is being

made in concert with agricultural chemists in many parts of the world with a view of determining the value of rain and snow as suppliers of nitrogenous plant food and of ascertaining the differences that may exist in the atmosphere in various countries in respect to richness in nitrogen compounds. The average per annum for the past five years so supplied is 6.18 lbs. of nitrogen per acre.

Water Supply of Farm Homesteads.

Because of the practical importance of the work I cannot omit some mention of the examination of waters from farm wells, creameries and cheese factories. Every year we find an increasing interest in this matter of a pure water supply on the farm, and though not of the nature of a scientific research, I have every reason to believe that our labours in this connection—which means the examination of some hundreds of waters annually—have been instrumental in improving the supplies of the farm homesteads throughout the length and breadth of the land. There is no better watered country in the world than Canada, but too often, alas, health has been sacrificed to convenience, and the farm well, because badly located, is a source of disease rather than one of good health.

In closing, a few words must be said about our directly educational work. In addition to our reports and bulletins, there is a very large and ever-increasing correspondence in all the departments. Farmers have the privilege of writing us without even the cost of postage on their letters, and they have not been slow to avail themselves of the privilege. Questions on all matters relating to general and special branches of farming daily pour in upon us, so that I can truly say we have become a Bureau of Information on agricultural subjects. And we encourage this branch of our work, for we seek, as we have done from the first, to keep in touch with the farmers and make the institution one of real assistance to the man on the land. In this, I believe, we have met with signal success, so that to-day the attitude of the farming people generally towards the Farms is one of confidence and receptiveness—an attitude that must tend to an ever-widening of the usefulness of the system.

The Experimental Farms have undoubtedly exerted an influence of great practical value throughout the length and breadth of the land, and I trust I may have been able in this imperfect and fragmentary presentation of their work, not merely to justify their existence but to furnish evidence of the wisdom and forethought of the Government in their establishment.