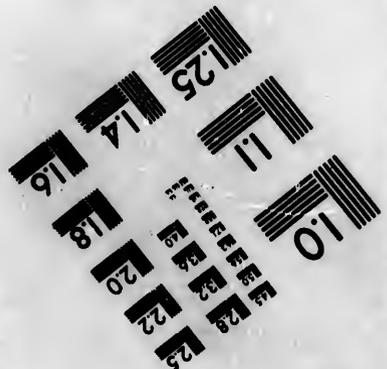
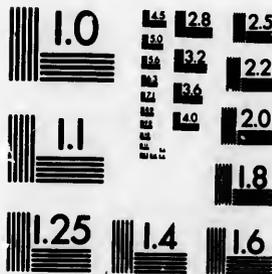


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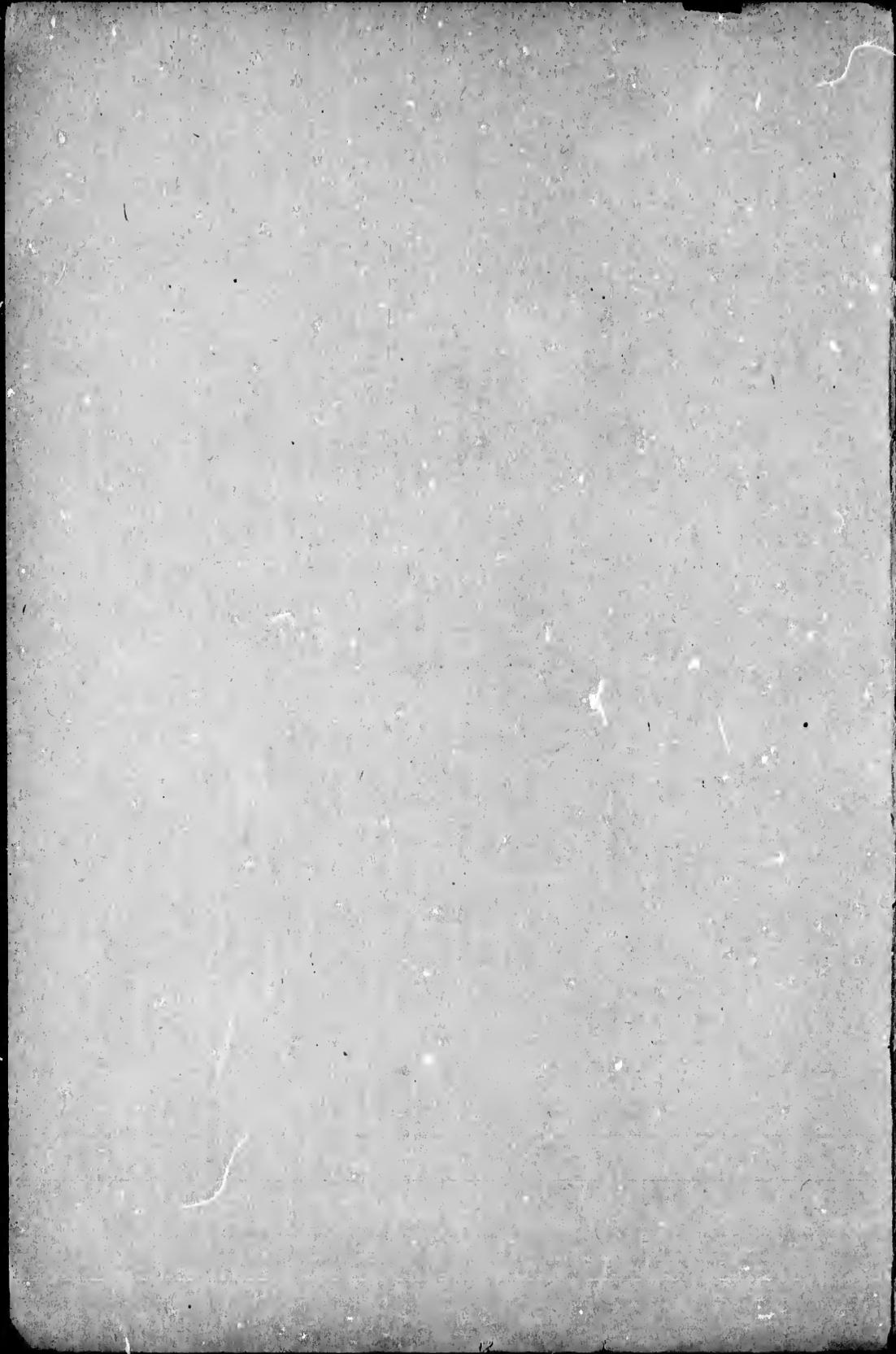
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Dominion Experimental Farms.

Read before the Natural History Society of Montreal, Somerville Course of Lectures,
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In bringing before you an epitome of the work accomplished for Canadian agriculture by the Chemical Division of the Experimental Farms during the past eight years, it may be advisable by way of introduction to say something of the important relationship that exists between Chemistry and Agriculture. And in order to make this relationship clear we may first consider briefly the character and scope of these two great sciences.

Chemistry busies itself with the study of the composition of all matter, solid, liquid and gaseous—living and inert—and endeavours to ascertain the laws that govern the changes which such matter is continually undergoing in the animal, the vegetable and the mineral kingdoms. Thus, chemistry has found out the nature of plant constituents and the source whence plants obtain them. It indicates the various food elements and the proportions in which plants take them from the atmosphere and from the soil respectively. Hence, not only soil exhaustion and diminished yields resulting from the practice of continually cropping without any concomitant return of soil plant food, become easily understood with the aid of chemistry; but the way for a more or less speedy return to fertility is indicated. In other words, by analysis and vegetation experiment (the latter practically a synthetical method) the

peculiar requirements of our farm crops are ascertained and economical means of supplying these wants are suggested. After studying the conversion of soil substances and of the constituents of the air into vegetable tissues, chemistry further endeavours to learn the function of these latter when used as food by animals. Thus, experimental research has shown that starch, sugar, gums, etc. (the class of nutrients known generally under the term carbohydrates) fibre and oil, products of vegetable metabolism are chiefly of service in the animal system in producing heat and supplying energy for work, while the albuminoids or nitrogenous organic matter elaborated by plants find their chief function as flesh formers and in supplying the requisite constituents for the production of blood, milk, wool, etc.

It may be urged that these are for the most part questions of vegetable and animal physiology, and rightly so; but is not physiology a name for that special branch of chemistry that seeks to explain the changes in matter that attend or are produced by the vital functions of plants and animals? At all events, physiology is largely chemistry, for if the former science tells us that living matter is composed of cells capable of nutrition and reproduction, the latter shows how the changes of the matter within the cells, primarily leading to their nutrition, and secondarily to their reproduction, are true chemical transformations.

Concerning Agriculture, we may say, adopting a definition given for English grammar by an old author that it is "both a science and an art." It is the oldest of all arts, save perhaps that of the chase. The art of husbandry includes and imparts skill in all farming operations—draining, plowing, harrowing, seeding, cultivating, harvesting, threshing, and indeed all work concerning the culture of the field and the care of farm animals. Of late years great progress has been made in agriculture as an art, and this principally through the introduction and assistance of improved implements and machinery. The sickle and the flail are almost forgotten instruments of the past, and many of the implements—

triumphs in mechanics—now in general use were not even faintly foreshadowed twenty-five years ago.

The science of agriculture first makes plain the reason for and the results of the various operations we have just enumerated and then studies the whys and wherefores of the changes brought about by nature through plants and animals. If agriculture as a whole may be said to have for its object the economic production of plants and animals and the materials elaborated by them during their life, agriculture as a science endeavours to ascertain the causes and conditions that lead to the consummation of this object.

Although Botany, Zoology, Physiology and Physics all lend their aid, it will be apparent from what I have said that Chemistry furnishes the basis and a large proportion of the superstructure of scientific agriculture; indeed, so interwoven and intimately connected is chemistry with all branches of farm work that agricultural chemistry and scientific agriculture may be counted as almost synonymous terms, for it is difficult to conceive an agricultural problem that does not make demands upon chemistry for its solution. It is most certainly true that agriculture is fast passing beyond the ranks of empiricism. We recognize that it has entered the realms of science; and the hope for the future of agriculture, as has been well remarked by an eminent English authority, lies in the larger adoption of those methods which science with practice advocates.

Interesting, however, as these considerations are, we must pass to the matter in hand and show wherein assistance has been rendered by the Dominion Government to Canadian agriculture by the chemical researches carried on in our laboratories at Ottawa.

VIRGIN SOILS OF CANADA.

The factors of a soil's fertility may be briefly enumerated as follows:—

- 1 The amount and availability of its plant food
- 2 Its mechanical condition or tilth.
- 3 The conditions of climate, rainfall, temperature, etc.

It is thus apparent that the knowledge afforded by a chemical analysis, when properly interpreted, is of great value as an indication of a soil's productiveness and for suggesting its economical treatment with fertilizers. A complete soil analysis comprises a series of most careful and accurate chemical operations, the determining of the amounts of plant food and more especially of the nitrogen, potash and phosphoric acid. Since such work necessitates a considerable expenditure of time, only typical soils, representative of large areas that have never been cropped or manured, are submitted to complete analysis.

As might be expected, the soils in Canada are exceedingly varied as regards their origin, their nature and composition. We have not yet the data that would enable us to speak of all classes of Canadian soils, for considering the area of the arable land in the Dominion, the work accomplished can scarcely be said to do more than give us information regarding the soils of widely isolated districts. Our endeavour will be, as opportunity offers, to continue this chemical survey and thus gradually accumulate data that will be of service, directly to our own farmers and of interest and value to those of other countries who may be meditating emigration to the Dominion by bringing before them a knowledge of the character of Canadian soils.

To mention a few of the more typical soils of the various provinces, I might, beginning in the West, tell you of the rich and fertile soils from the valleys of the Fraser and Pitt Rivers in British Columbia.

These alluvial deposits, composed of detritus, cover many thousands of acres, and rank, both as regards mechanical condition and richness of composition, with the best soils of any country in the world. Of nitrogen, potash and phosphoric acid, as well as of the minor elements of plant food, analysis has proved them to contain large stores. Undoubtedly, the soils formed by the deposits of other rivers in the province would show themselves on examination to be equally rich in plant food.

Another class of soils in British Columbia are the upper "bench" soils. Those analysed have been of a light and sandy character, considerably inferior to the soil just referred to as regards plant food, but, nevertheless, owing to the extremely favourably climatic conditions that prevail, have proved themselves to be capable of producing good and profitable yields.

British Columbia also possesses in many of her valleys areas of mucky soils, essentially rich in organic matter and nitrogen. These with proper treatment are exceedingly productive and eventually will prove of great value for the growing of most of our farm crops.

Concerning the soils of the North-West Territories, I can state that most of those samples examined have been found to contain large amounts of plant food. Even soils from the areas affected by the deleterious presence of alkali for the most part contain all the necessary elements for productiveness, and only await the proper treatment of drainage and the application of certain chemicals to make them fertile in a high degree.

The prairie soil of Manitoba constitutes a real mine of plant food. A sample examined from the Red River valley, a black loam more than two feet in depth, was of a very high order, possessing remarkable amounts of all those materials which crops require, and ranking as pre-eminent from both a chemical and mechanical standpoint. From the analysis, I calculated that an area of one acre to the depth of one foot, contained, approximately: Nitrogen, 33,145 lbs; Potash, 33,950 lbs; Phosphoric acid, 9,450 lbs. When we compare these amounts with those present in average fertile soils, viz: Nitrogen, 3,500 lbs; Potash, 7,000 lbs; Phosphoric acid 6,000 lbs., the great agricultural value and possibilities of this prairie soil will be obvious.

Both the North-West Territories and Manitoba are justly noted as grain growing areas and more especially for producing large yields of wheat rich in gluten and of excellent milling qualities. The magnificent soil of these districts has been one of the chief factors in bringing about this result. Our farmers

in the far West, however, should learn before too late that this store of fertility is not inexhaustible and that the export of grain results in soil exhaustion which must be met by the application of manures and fertilizers if the present conditions are to be preserved. Undoubtedly, the climate there prevailing is one that assists in the conservation of soil plant food, but this factor, obviously, is not one that should be relied on to the neglect of replacing plant food.

The difficulty of obtaining in Ontario samples of virgin soil representative of large areas has prevented me hitherto from being able to draw any conclusions that would be of general importance and value. As data accumulate, we may be in a better position to speak more definitely and probably to map out this province into districts according to the original character of its soils. In the meantime, we can report that in most instances the results we have obtained show a sufficiency of plant food for lucrative crops yields.

Unfortunately the practice of "burning" when clearing up land has been most disastrous over large districts, destroying vast stores of humus and nitrogen, a loss that can be replaced only by many decades of skilfull procedure and care.

From the Province of Quebec both heavy and light soils have been received. Many of the frontier lands are in a condition of partial exhaustion, owing to the one-sided method of farming that has been in vogue. These must be built up with green manuring and by application of barnyard manure and fertilizers, thus replacing those elements that many years of cropping have taken away. Undoubtedly, the virgin soils of the areas here referred to were just as rich in plant food as those of any province in Canada, a statement that receives corroboration from results obtained in the examination of certain newly broken Quebec soils.

Hitherto, the soils from the Maritime Provinces examined by us have been few in number. Such data, as we have however, would go to show that their virgin soils are capable of giving excellent crops under proper treatment.

In closing this cursory review of our work in this branch of agricultural investigation, it only remains to say that our examination of Canadian cultivated soils points to certain economic methods of improvement that may be recommended to our farmers in order to enhance the productiveness of their fields.

These briefly are as follows :—

1 The more extensive growth of the legumes (peas, beans, clover, etc.). These plants alone have the ability to assimilate the free nitrogen of the air and thus are particularly valuable for "turning under" and also as fodder crops. Green manuring (the ploughing under of a green crop) with clover adds to the soil's store of fertility in nitrogen and humus, improving the soil both chemically and mechanically.

2 The application of wood ashes to supply the second essential element of plant food, viz: potash. Canadian wood ashes (in other words, Canadian soil fertility), though much undervalued at home, find a ready sale in the United States. Our farmers receive in exchange for their ashes but a tithe of their worth. Does not parting with them under such conditions seem like killing the goose that laid the golden egg? If wood ashes are not obtainable, muriate of potash or kainit (a potash salt mined in Stassfurt, Germany) should be used to supplement the barnyard manure.

Again, there are many of our soils and crops that would be benefited by an application of a soluble phosphate. Apatite or mineral phosphate of lime we have in Canada in abundance and also the raw materials for manufacturing the sulphuric acid to treat it with and make it soluble. It only remains for our farmers to intelligently use the superphosphate in order to increase the fertility of their fields and at the same time assist an industry that would be of great importance to the country.

3 Compared with the soils of other countries, many in Canada appear to be deficient in lime. This fact suggests that the judicious application of lime, marl or gypsum (at the same time supply other forms of plant food) would lead to good re-

sults. We have ample testimony that on many of our heavy and light soils this treatment has been eminently satisfactory.

NATURALLY-OCCURRING FERTILIZERS.

Closely relating to the question of soil plant food is that of fertilizers. In many parts of the Dominion are to be found vast deposits of material rich in the elements necessary for plant growth. These accumulations of swamp muck, peat, marl, gypsum, moss, river and tidal muds, seaweed, etc., etc., are all most valuable. Their composition should be better known and their methods of application more universally understood. Analyses made in our laboratories have established the fact that swamp mucks are nitrogenous fertilizers of a high order. In an air-dried condition they will average per ton between 30 lbs. and 40 lbs. of nitrogen which element by suitable fermentation may be converted into assimilable forms for crop use. Moreover, we have ascertained that this material (air-dried) is an excellent absorbent so that it can be used to advantage in and about our farm buildings and indeed everywhere where there is liquid manure to absorb. By its use in this way not only is the most valuable portion of the manure saved from loss but the buildings, the farm and the yard well kept clean. The fermentation that subsequently ensues in the manure pile results in the production of a rich and quick acting fertilizer. These deductions are drawn from over one hundred analyses made by us of muck collected in the various provinces of the Dominion.

A word or two about moss litter. During the past year an investigation was made in our laboratories of samples of peat moss from New Brunswick. The results obtained established a high value for this substance as a bedding material. Its absorptive capacity is high, the air-dried moss holding as much as 16 and 18 times its own weight of liquid. Not only is it useful in keeping stables dry, but also preserves them free from odour, for it has the property of absorbing ammonia and other gases. Moss litter (principally species of *Sphagnum*) contains about half of one per cent of nitrogen, as well as notable quantities of other

fertilizing ingredients. The resulting manure ferments well and is of excellent quality. Here again we have an opportunity to establish a lucrative business in Canada—one of value, not only to agriculture but to commerce generally; for moss litter is in great demand for use in the stables of the larger cities of the United States.

We must pass over our deposits of marl and gypsum, merely recording the fact that our analytical work in the Farm laboratories has shown that we have, in many districts, in a cheap and obtainable form just that element which many of our soils require to bring them into a high state of productiveness.

Seaweed from the Atlantic and Pacific coasts of Canada has been analysed by us, and its value as a manure, on account of the potash and nitrogen it contains, well established. The ease and rapidity with which this fertilizer decays in the soil, liberating its constituents in forms at once available for plant use, greatly enhance its value.

The tidal deposits of the Maritime Provinces, and more especially of the Bay of Fundy, have received careful examination at our hands. Their beneficial action has been shown to depend not only upon the nitrogen and organic matter they contain, but also upon the somewhat small amounts of the other essential elements of fertility they possess or of the carbonate of lime they supply. While not of the character of commercial fertilizers in the quantities of plant food they contain, they are undoubtedly valuable for many soils as amendments, both chemically and physically. As they differ very much, it is exceedingly difficult to speak of these muds as a class. While some are but of the nature of fair soil, others on examination are found to contain notable quantities of nitrogen, potash, phosphoric acid and lime.

FODDERS AND FARM CROPS GENERALLY.

There is now such a large accumulation of analytical data respecting the composition of our native and introduced grasses, clovers, Indian corn, roots of all kinds, cereals and milling bye-

products, that it will only be possible for me on the present occasion to refer to a few of the more important features of this work and to direct your attention to those conclusions that seem to be of special interest to us as Canadians.

In 1888 we began an examination of our wheat, the results being published in Bulletin No. 4 of the Experimental Farm Series. That work was almost exclusively confined to wheat grown in Manitoba and the North-West Territories. Not only was the composition of the grain ascertained, but as far as possible the influence of climate, soil and cultivation upon the wheat were studied. Our analyses of the western wheats showed besides other good features, a large percentage of albuminoids (gluten). Both the physical and chemical data testified to the excellent milling qualities and the high nutritive value of the Red Fife as grown in the provinces referred to. The effect of environment upon wheat is an interesting study, but one into which we cannot to-night examine with minuteness. It must suffice to state that the conditions of the North-West appear to be particularly favourable to the increase in the most important constituents of the wheat, viz: the albuminoids the percentage of albuminoids (or flesh-formers) present being the chief factor used in grading and valuing wheat.

Further analytical work on Canadian cereals was that done by me when acting as a professional juror at the World's Columbian Exposition in Chicago in 1893. Of 166 samples of wheat submitted to analysis, 49 were from Canada. The data, which are published in my report now in press, again furnish ample proof of the very excellent qualities of the wheat from Manitoba and the North-West Territories. Indeed, the averages from these provinces are fully equal to those afforded by the best grain growing districts of the world. The samples submitted by the Province of Ontario at this Exposition had not been selected with care or skill, and, as a result, the general Canadian average of quality appears to be much lower than it really is.

From our analyses, the points in favour of Canadian oats appear to be (1) a heavy kernel, (2) a low percentage of moisture, (3) high albuminoids and (4) a large percentage of fat. It must be remembered, however, that oats, like wheat, are greatly influenced in composition by their conditions of growth, and, therefore, while there are many samples exhibiting the qualities I have mentioned, there are many districts in which by careful cultivation the feeding value of the oats might be increased.

THE GRASSES OF CANADA.

The enormous importance to our farmers, stock raisers and dairymen of palatable, nutritious and cheap fodder led to a determination of the food constituents of many species of native and introduced grasses. The analytical data already published have been largely obtained from the examination of grasses grown under the care of the Botanist of the Farm at Ottawa, though a considerable number of samples from Manitoba were also analysed.

Grasses may be divided into two agricultural classes; pasture grasses and meadow grasses, those of the first class springing up well when eaten off, those of the second being characterized by yielding a heavy crop of hay. The requirements of a good grass are: (1) That it should produce a heavy crop; (2) That it should be hardy; (3) That it should be rich in the more valuable food constituents; and (4) that it should be palatable.

Of native pasture grasses, I can speak in special commendation of June Grass (*Poa pratensis*), a rich, palatable perennial. In all respects it is a most excellent pasture grass, abundant everywhere and worthy of more careful cultivation. A careful study of this grass (sometimes known as Kentucky Blue Grass) led Mr. Fletcher, the Botanist of the Farms, and myself to the conclusion that it was "undoubtedly the most valuable pasture grass in the Dominion."

Red Top (*Agrostis vulgaris*), though not a native grass, is now very common. This also is a valuable grass and one

especially adapted for low lying lands, where it may well find a place in permanent pasture mixtures.

Austrian Brome Grass (*Bromus inermis*) is an introduced perennial, hardy, and a heavy cropper, producing a good aftermath of excellent feeding quality. By reason of the richness of its composition and its luxuriant habit of growth, it is certainly one of the most valuable of the introduced grasses.

Orchard Grass (*Dactylis glomerata*). This is a grass which responds well to liberal treatment, giving large crops on rich soils and particularly suitable for shady pastures.

These must suffice as types or illustrations of our work in the examination of Canadian grasses—the complete series comprising nearly three hundred analyses. I would, however, refer to some general conclusions, drawn from this investigation, regarding the right period at which to cut for hay.

In analysing the same grass at different stages of growth, it was noticed that certain changes of composition take place as the plant approaches maturity; the percentages of water, ash and albuminoids and fat decrease, while the percentage of fibre and usually the nitrogen free extract increase. In the younger stages, the grass is more succulent and palatable, and our work also shows that it is during the earlier weeks of growth that the plant's nitrogen and mineral matter are taken from the soil—which point to the advisability of thoroughly preparing the seed bed by cultivation and fertilizing, and to the value of top dressings with nitrate of soda while the crop is still young.

Further, the data we obtained allow us to infer that a loss of much valuable and digestible food material occurs when a grass is allowed to thoroughly mature before it is cut for hay. Scientific evidence is all in favor of cutting at or shortly after the flowering period.

INDIAN CORN.

No account of the coarse or bulky fodder plants of Canada would be complete without some reference to the character of the Indian corn crop, one which ranks next in importance to

grass, and certainly the one which above all others has made winter dairying possible and profitable.

Owing to the large yields obtained and its succulent and nutritious character, corn furnishes one of the best and certainly the cheapest of our bulky fodders. An immense amount of chemical work has been done in our laboratories to ascertain, (1) the requirements of this crop, (2) the relative value of certain varieties for feeding purposes, and (3) the best time for cutting, whether for the silo or for preservation in the dry condition. Our data on this subject are voluminous. I can now but refer to one or two of the more important conclusions.

Analyzing the principal varieties at five different stages of growth and ascertaining the weight of the crop per acre at the same periods, we learned that a variety coming to early maturity (known as the glazing condition) would at that stage afford nearly twice as much real cattle food per acre than if cut a month earlier. The more practical deductions from our chemical work may be summarized as follows :

1. That the ground should be well prepared and rich in available plant food constituents, and more especially in potash.
2. That such varieties should be planted as will in all probability come to maturity before danger from frost.
3. That corn should not be sown broadcast ; for vigorous growth and in order to come to maturity it requires plenty of room for both roots and leaves.
4. That cutting either for the silo or for drying in stock should be delayed (unless it is touched by early frost) until the corn reaches the glazing condition.

Other fodder crops, including clover, beans, rye, and roots of all kinds, have been carefully studied and their requirements and relative feeding values made known for the guidance of our farmers. Since the profits in farming to-day depend as much upon cheap production as upon good prices ; the value of the knowledge of cheap and efficient feeding materials is obvious.

FRUITS AND VEGETABLES.

Canadian Horticulturists are being assisted by the chemical investigations instituted with the view of ascertaining the special requirements of our fruit trees. The knowledge thus afforded will lead, I trust, to the more economic and profitable application of fertilizers. Already reports on the chemistry of the apple and strawberry have been published, and further contributions will be issued shortly.

Spraying in order to prevent and check the ravages of insects and fungus foes is now recognized as an indispensable operation by all progressive orchardists. Without Bordeaux mixture and Paris green we can no longer gather a harvest of apples free from spot and the inroads of the Codling Moth. It has been our duty, therefore, to examine into the chemistry of these insecticides and fungicides, in order to obtain an exact knowledge of their constitution, modes of action and best methods of preparation.

WELL WATERS OF FARM HOMESTEADS.

Of the many lines of research in Agricultural Chemistry that we have prosecuted since the establishment of our laboratories, few have been of greater importance than the examination of the well waters of Canadian farm homesteads. Though the natural waters of the Dominion as found in the rivers, lakes and springs are the purest, the equal in wholesomeness and good quality of the best to be found in any country, the water used by the farmer and his cattle is too often of a most pernicious character. It is very much to be regretted that so many of the samples received by us from farmers were seriously polluted. It would appear that our farmers have been in the habit of locating, for convenience sake, the well in the barnyard or stable, or dangerously near some contaminating source. The result of this is that many wells are acting as cess-pits, and their impure waters are reeking with organic filth and disease-producing germs. We have at last awakened such an interest in this vital ques-

tion by the publication of our results and by addresses before conventions of farmers that concerted action by Ontario dairy-men is spoken of towards compelling all those sending milk to a creamery or cheese factory to have an ample supply of pure, fresh water, free from all drainage matter.

In the foregoing résumé I have not been able even to mention many important branches of work undertaken by the Chemical Division of the Experimental Farms. To those who would know more of the ways in which we endeavour to help Canadian agriculturists, or who may wish for further details of the work which I have brought before you to-night in outline, I would suggest the perusal of our annual reports and bulletins.

The national importance and value of these chemical investigations will be apparent when we reflect that Canada is essentially an agricultural country, that her future progress as a nation must in a very large measure be proportionate to the progress of her agricultural industries. It is not for me on this occasion to speak of her minerals and forests (which undoubtedly are stores of untold wealth); but it is my privilege and duty to say that I believe her to be a great food-producing country, that her prosperity lies chiefly in the pursuit of agriculture, in producing butter and cheese, in stock raising, in fruit-growing and in the cultivation of grain.

