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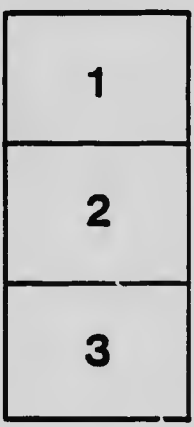

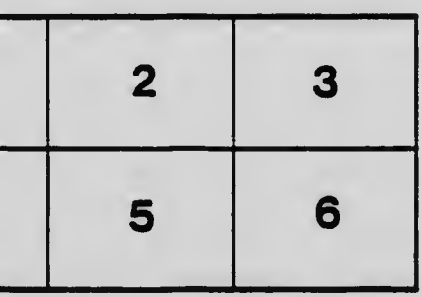

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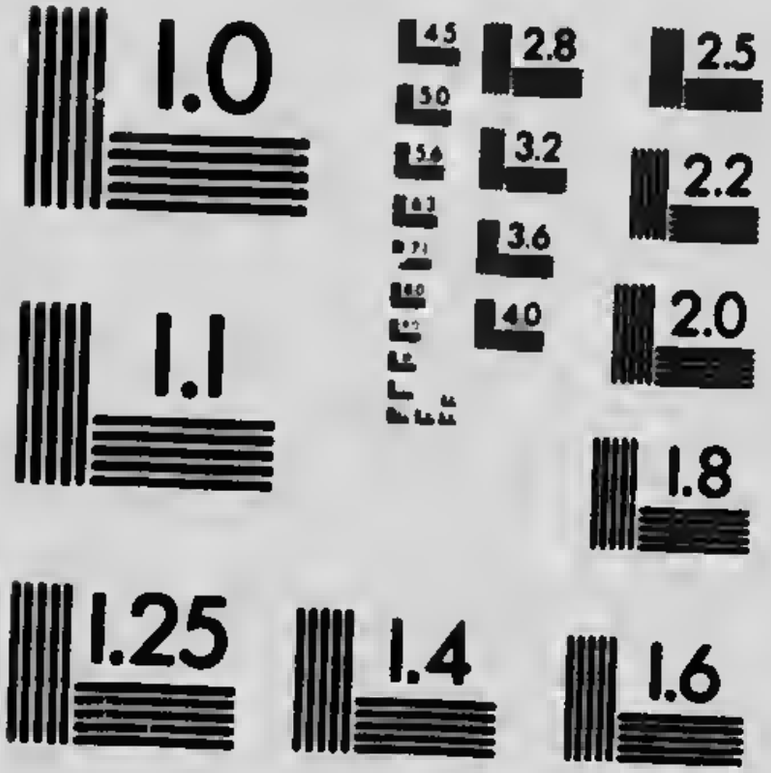

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DIVISION OF CHEMISTRY

MANURES AND FERTILIZERS

BY

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Dominion Chemist

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MANURES AND FERTILIZERS.

BY

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THE INCREASE OF FERTILITY THROUGH THE USE OF FARM MANURES, THE GROWING OF CLOVER AND THE APPLICATION OF FERTILIZERS.

It may be useful in these days, when we are seriously considering all possible means that may lead to a profitable increase in our crop yields, to review the more important conclusions that have been reached on the Experimental Farms from experiments conducted towards the increase of soil fertility.

This investigation has included trials with manure, fresh and rotted, fertilizer ingredients singly and in mixtures, applications partly of manure and partly of fertilizers and experiments to ascertain the manurial values of the aftermath and of the residues left by clover and by several other of our more important legume crops. Many of these experiments have been conducted over a period including several complete rotations.

For the most part, these trials have been carried on at Ottawa, on a rather light and sandy loam, somewhat poor in humus and apt to suffer seriously in times of drought. But there have also been, to a limited extent, similar experiments on several of the branch Farms, on heavier soils, so that considerable weight may be attached to the conclusions as being more or less generally applicable.

MANURE: THE MOST EFFECTIVE FERTILIZER.

Our work has emphasized the value of barnyard manure. The yields of our staple crops have been higher on plots dressed with manure at the rate of from 10 to 15 tons per acre, than on our plots receiving commercial fertilizers applied in various mixtures and proportions according to the best known practice.

MANURE: THE VALUE OF FREQUENCY IN APPLICATION.

[illegible] the after effect, that is, the influence on subsequent crops, of manure [illegible] marked than in the case of fertilizers, it is evident that comparatively [illegible]ations at short intervals are more effective than larger dressings applied [illegible]y. Thus, on most soils, but more especially light loams, 5 tons per acre e[illegible]d year will give better return than 10 tons every sixth year.

KEEP THE MANURE NEAR THE SURFACE.

The larger number of the feeding roots of our staple farm crops in humid districts are within the first 6 inches of soil, indeed for many crops the foraging ground may be restricted to four inches. For districts where methods of so-called "dry farming" must be employed and the roots seek moisture at greater depths, this statement must be modified. Nevertheless, taking the country as a whole, there is no economy in burying the manure at any great depth. Its equable and uniform distribution, as by a manure-spreader, and thorough incorporation with the surface soil, as by shallow ploughing, or perhaps better still by disc harrowing after the manure has been spread on the partially prepared soil, appears to be the most profitable practice.

FRESH VERSUS ROTTED MANURE.

Weight for weight, fresh manure has given crop yields almost equal to those from rotted manure. Since the latter, under careful conditions of rotting, contains larger percentages of plant food constituents, this seems surprising. It is nevertheless the case, for it is the result of many repeated experiments, extending over a long period of years. Explanations might be offered from the standpoint of chemistry, of biology, and of physics, but they would be largely conjectural and their discussion would not serve any useful purpose in this brief review. The fact remains.

The losses that occur in the rotting of manure have been carefully and repeatedly determined. Under the very best practice—that of keeping the heap *compact and moist and protected from leaching rains*, the losses are considerable; under careless methods involving excessive fermentation or leaching, or both, they may be enormous. The losses due to high fermentation fall on the organic matter and nitrogen; those due to leaching are chiefly in nitrogen and potash. Our experiments would go to show that, under the conditions as found on the ordinary farm, the loss in rotting is from one-third to two-thirds of the initial value of the manure.

All this emphasizes the economy of applying manure to the land as soon as possible after its production, fresh and direct from the barn and stable, so far as that may be practicable. The soil is its best storehouse. The products of its decomposition, if formed within the soil, are held therein for soil improvement and future crop use.

MANURE HAS A GREATER VALUE THAN INDICATED BY ITS PERCENTAGES OF PLANT FOOD.

Manure has a much higher crop-producing power than would be indicated by its percentages of nitrogen, phosphoric acid and potash. This has been abundantly shown by the larger yields from the plots receiving their quota of plant food partly in manure and partly in fertilizer as compared with those receiving it entirely as fertilizer.

This is readily explained. Manure furnishes humus-forming material. Humus is probably the most valuable of all soil constituents, improving its tilth, increasing its water-holding capacity, supporting its microbic life and by its decay acting as the direct source of available plant food. In these particulars, fertilizers play no part for they do not furnish any humus-forming material. In a word, fertilizers are no substitute for manure; to be used profitably we conclude they must be employed to supplement the stock of manure. We cannot hope to carry on farming profitably by the exclusive use of fertilizers.

THE MANURIAL VALUE OF CLOVER.

The value of clover and other legumes for increasing the fertility of the soil has been exhaustively studied. The unique property of appropriating atmospheric nitrogen through the agency of bacteria residing in the nodules attached to their roots, has been abundantly emphasized by our investigations. By this means from 50 to 100 pounds of nitrogen per acre may be added to the soil that will subsequently be available for crop use. In field demonstration it has been repeatedly shown that crop yields, after turning under an aftermath of clover, fully equalled those from land dressed with manure at the rate of 10 tons per acre. The high manurial value of the legumes has been well established, and all our work in this connection has been most satisfactory, encouraging and conclusive.

FERTILIZERS: THEIR VALUE AND FUNCTION.

It would seem impossible to predict with any certainty the return from fertilizers. The results are most erratic, depending not only on the character of the land and the nature of the crop but also in a large degree upon the season. It has been shown, how-

over, over and over again, that, judiciously used, a profit may be obtained from fertilizers. The question is not merely one of increasing the yield, but of obtaining the maximum yield at the minimum expenditure. In many instances an increased yield has been obtained with the cost of the fertilizer exceeding the value of that increase. Profits, therefore, are to be regarded in this work rather than yield, though naturally the two are as a rule closely associated. Fertilizers appear to pay best on high-priced crops, such as potatoes.

The best returns from fertilizers, that is the largest profits, do not necessarily result from excessive or even very large applications of fertilizers. In our experimental work, many of the largest profits have resulted from comparatively small dressings—from 300 to 500 pounds per acre. This points to the conclusion that the function of fertilizers is to raise the small proportion of *available* plant food in the soil rather than to increase materially the amount of the *total* plant food therein contained. If future work confirms this conclusion, the availability of the elements in the fertilizer is a matter of even greater importance than we at present deem it. It would seem from our work that it would be altogether too expensive to try to build up a soil, to materially increase its percentages of the elements of plant food, simply by the use of fertilizers.

A COMPLETE FERTILIZER DESIRABLE.

Our experiments with fertilizers have included trials with various forms of nitrogen, phosphoric acid and potash, singly and in combinations. Nitrate of soda alone and applied as a top-dressing early in the season has frequently proved beneficial for hay and grain crops on soils poor in available nitrogen. Similarly, superphosphate has occasionally given a good response on turnips and basic slag on old pastures. But in the larger number of instances, and more particularly on corn and roots, including potatoes, we have found it more profitable to use a complete fertilizer, that is, one furnishing nitrogen, phosphoric acid and potash. We therefore are of the opinion, in general practice and unless there are special considerations, that it is wise to use a complete fertilizer; experience has shown that such entails less risk of failure.

NITROGENOUS FERTILIZERS.

Probably the chief crop among those receiving fertilizers is that of the potato, and most of our recent work in this connection has been done primarily on that crop. The larger number of the experiments have shown that for the potato the nitrogen is best applied partly as nitrate of soda and partly as sulphate of ammonia. This permits of a more or less continuous supply of nitrogen throughout the growing season. On land in fair condition, as for instance one prepared by ploughing under a good clover sod which has been lightly dressed with manure, the results at several of the branch Farms indicate that an application of 75 pounds nitrate of soda and 75 pounds sulphate of ammonia per acre, marks the approximate maximum dressing that can be given with profit.

Organic forms of nitrogen, such as fish waste and tankage, are more particularly useful on moderately heavy, warm, moist soils, promoting growth more especially during the latter weeks of the season. Hence, they are not ideal forms when a quick response is required in the spring or early summer, but are better suited for long-seasoned crops. A cold, wet spring retards their nitrification and in some seasons their nitrogen may not become available till well on in the summer when the crop has passed the period of its chief vegetative growth. Similarly, they may be comparatively dormant in light soils during seasons of drought. More work, on different types of soils and under various seasonal conditions, is necessary before final conclusions can be reached as to the role and comparative value of these organic forms of nitrogen, but this much may be said that in several instances in which no appreciable response

was observed on the crop of the year of application, a favourable influence was noticeable on the succeeding crop. Of all classes of fertilizers, these no doubt approach more closely the farm manures, in their lasting character and in adding to the soil's store of organic matter.

PHOSPHATIC FERTILIZERS.

The choice of a phosphatic fertilizer will depend largely on the character of the soil to which it is to be applied. For soils rich in lime, superphosphate (acid phosphate) will give the quickest return and especially for crops that need, in their early stages, the stimulus afforded by immediately available phosphoric acid, e.g., the turnip crop. Superphosphate is also an excellent form for the cereals, in conjunction with nitrogen. The profitable application is in the neighbourhood of 300 pounds per acre.

For all sour soils, many clay loams deficient in lime, peats and mucks, basic slag has proven the most desirable form. It is an alkaline phosphate containing a certain amount of free lime. It contains no water-soluble phosphoric acid but nevertheless yields this element fairly readily for crop use. The dressing may be from 300 to 500 pounds per acre. Bone meal has proved a valuable fertilizer, more especially on the lighter loams that do not dry out too readily. It requires a well aerated and moist soil for its best results. It is essentially a phosphatic fertilizer, but undoubtedly a part of the response obtained from its application is in many instance due to its nitrogen, which, according to the method of its preparation, may vary from 1 to 4 per cent. It would seem to be most suitable for crops with a long season of growth. The application is usually about 500 pounds per acre, and has given good returns in conjunction with wood ashes—say 25 to 40 bushels per acre—to supply potash.

POTASSIC FERTILIZERS.

No potassic fertilizers has proved more valuable than good hardwood ashes. They present their potash in the form of carbonate which appears to be ideal for crop use. Further, they furnish a notable amount of phosphoric acid (about 2 per cent) and contain a considerable percentage of carbonate of lime, which is particularly efficient on light sandy loams and on peaty and muck soils. The application may be from 25 to 40 bushels per acre, the latter dressing being used by orchardists and market gardeners.

Muriate of potash and sulphate of potash are the two potassic fertilizers put on the market from the Stassfurt mines. Of the highest grade, they are practically identical as to potash content—about 48 per cent. They have been used more especially for the potato crop the sulphate being preferred, as the muriate, it is alleged, results in an inferior quality of tuber. Our experiments have shown these two compounds to be equally effective as to yields, with no marked inferiority in quality due to the muriate.

Of late years the percentage of potash in many brands of fertilizer intended for the potato crop has been steadily increased, in response to a demand for a fertilizer with a high potash content. A few years ago 2 per cent of potash in a fertilizer was considered rich enough; recently brands containing 8 per cent and 10 per cent have not been uncommon. The results of our experiments have not borne out this belief in the value of large dressings of potash. The maximum application of muriate of potash that has yielded a profit has been 100 pounds per acre (approximately 50 pounds potash) and not infrequently a dressing of 50 pounds per acre has marked the limit of profitable application. On heavy clay soils, potash fertilizers are not, as a rule, remunerative, but as already remarked, they are chiefly required by sandy, gravelly soils and those rich in organic matter, such as peat and mucks.

SUMMARY AND ADVICE.

Rational farming is "mixed" farming, by which we understand the keeping of stock to consume a large proportion of the crops grown on the farm. Thereby the farmer uses animals as living agents to convert low-priced material (hay, roots, straw, etc.) into high-priced products which, sold to the city consumer, take from the farm comparatively little of the plant food of its soil and leave manure, the very best, the most valuable of all sources for economically maintaining and increasing fertility. Barnyard manure is unquestionably the most effective of all fertilizers.

Our chemical work has shown that the liquid portion of the manure is by far the more valuable for it is not only richer in nitrogen and potash that is the solid, but these elements are present in a soluble and immediately available condition and can be at once utilized by crops. It is therefore, the part of wisdom to use sufficient litter in the barns and stables to absorb all the liquid. If the supply of straw is short, sawdust and air-dried peat or muck may be employed as supplemental litter.

On the larger number of Canadian farms, the amount of manure produced is insufficient to keep all the land at its limit of production. We must therefore use it judiciously and to this end we advocate frequent light dressings, rather than larger ones at longer intervals. The manure is most advantageously applied for the root or corn crop in the rotation.

Although the constant aim should be towards deepening the surface soil—the chief feeding zone of our crops—this should be undertaken gradually, especially with naturally poor soils. In so far as this is brought about by manuring, we believe that it is not wise to "bury" the manure. A shallow ploughing under, or the incorporation by the means of the disc harrow, is for most soils and crops the most profitable practice.

Manure is never worth more for the general improvement of soils than when first voided. Since losses in humus-forming material and in the elements of fertility inevitably result from rotting; it follows that the sooner the manure is in the soil—its very best storehouse—the larger the return that may be expected from the farm's supply. Moreover, practical experiments conducted over a number of years have shown that for ordinary farm crops, fresh manure, weight for weight, has given yields almost equal to those from rotted manure.

The important part that manure plays in improving the tilth of the soil and in supporting the useful microbic life of a soil, has been well brought out so that we can truly say that manure has a greater value than that indicated by the percentages of plant food.

Rational farming involves a rotation of crops; there are many excellent reasons to support this statement which we need not here enumerate or discuss. We would, however, emphasize the value from the manurial standpoint of the place of clover, or other legume, in the rotation. Laboratory investigations and practical field tests have alike contributed in proving the high manurial value of clover, alfalfa and other members of this family. Their growth adds much nitrogen to the soil and this in a form more or less stable and at the same time usable by subsequent crops. This nitrogen is appropriated from an inexhaustible source—the atmosphere, which is thus harnessed as it were to enrich our soils. The value of the legumes in this connection is emphasized when it is remembered that of all the elements of plant food purchased in fertilizers, nitrogen is the costliest. Further, the growth of the legume enriches the soil in humus-forming material, so that in many ways these plants are in a very real sense soil improvers. The lesson is then grow a leguminous crop in the rotation, for thereby will not only much valuable feeding material be produced but the land will be benefited. All other crops save the legumes leave the soil poorer for their growth.

Commercial fertilizers cannot be depended upon profitably to maintain fertility. Their exclusive use is strongly discountenanced. They are no substitutes for manure, yet they may frequently be employed as supplemental to it with profit, more especially if the crop be a high-priced one, as potatoes. Their function in rational agriculture seems to be to raise the proportion of immediately available plant food. They are altogether too expensive to be used for the general building up of a soil. Their use at first should be experimental, for it is almost impossible to foretell what profit may result.

Nitrogen, phosphoric acid and potash are the three elements furnished by fertilizers. Fertilizer ingredients are readily purchasable and mixtures can be made without any expensive machine on the farm. By home mixing a saving of from 25 to 35 per cent may be effected, and this course is advised on grounds other than economy, for it puts the farmer in possession of information respecting the nature of the materials, their functions and the proportions most profitable to use, that will be of much value for his future guidance. The text of this bulletin enumerates the various fertilizer ingredients on the market.

A fertilizer containing all three elements has, in the majority of instances, proved the most profitable. Large dressings have not, as a rule, given as large a profit as small applications and the aim in experimenting with fertilizers should be to ascertain the minimum dressing for the largest return, or to put it otherwise, the maximum yield for the minimum expenditure. Profits rather than yields must be looked for.

The paragraphs relating to special nitrogenous, phosphatic and potassic fertilizers should be closely studied, for the information therein contained cannot well be further condensed. Particulars are there given which explain the nature and function of these and the amounts generally found profitable to apply are stated.

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