# Technical and Bibliographic Notes / Notes techniques et bibliographiques

The Institute has attempted to obtain the best original copy available for filming. Features of this copy which may be bibliographically unique, which may alter any of the images in the reproduction, or which may significantly change the usual method of filming are checked below.

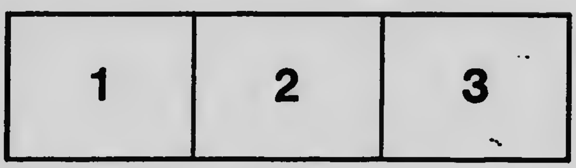
L'Institut a microfilmé le meilleur exemplaire qu'il lui a été possible de se procurer. Les détails de cet exemplaire qui sont peut-être uniques du point de vue bibliographique, qui peuvent modifier une image reproduite, ou qui peuvent exiger une modification dans la méthode normale de filmage sont indiqués ci-dessous.

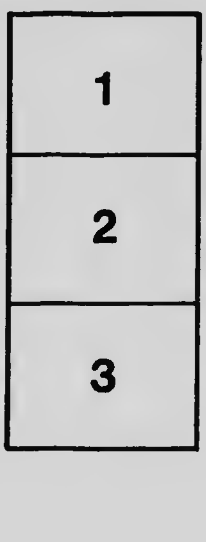
- [ ] Coloured covers / Couverture de couleur
- [ ] Covers damaged / Couverture endommagée
- [ ] Covers restored and/or laminated / Couverture restaurée et/ou pelliculée
- [ ] Cover title missing / Le titre de couverture manque
- [ ] Coloured maps / Cartes géographiques en couleur
- [ ] Coloured ink (i.e. other than blue or black) / Encre de couleur (i.e. autre que bleue ou noire)
- [ ] Coloured plates and/or illustrations / Planches et/ou illustrations en couleur
- [x] Bound with other material / Relié avec d'autres documents
- [ ] Only edition available / Seule édition disponible
- [x] Tight binding may cause shadows or distortion along interior margin / La reliure serrée peut causer de l'ombre ou de la distorsion le long de la marge intérieure.
- [ ] Blank leaves added during restorations may appear within the text. Whenever possible, these have been omitted from filming / Il se peut que certaines pages blanches ajoutées lors d'une restauration apparaissent dans le texte, mais, lorsque cela était possible, ces pages n'ont pas été filmées.
- [ ] Additional comments / Commentaires supplémentaires:

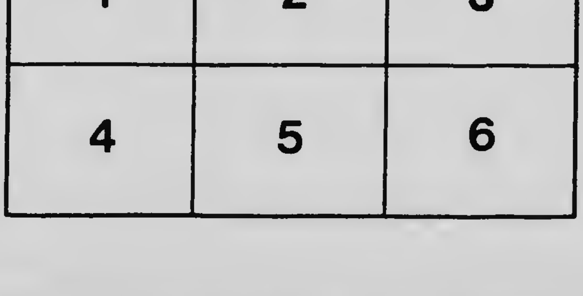
- [ ] Coloured pages / Pages de couleur
- [ ] Pages damaged / Pages endommagées
- [ ] Pages restored and/or laminated / Pages restaurées et/ou pelliculées
- [x] Pages discoloured, stained or foxed / Pages décolorées, tachetées ou piquées
- [ ] Pages detached / Pages détachées
- [x] Showthrough / Transparence
- [ ] Quality of print varies / Qualité inégale de l'impression
- [ ] Includes supplementary material / Comprend du matériel supplémentaire
- [ ] Pages wholly or partially obscured by errata slips, tissues, etc., have been refilmed to ensure the best possible image / Les pages totalement ou partiellement obscurcies par un feuillet d'errata, une pelure, etc., ont été filmées à nouveau de façon à obtenir la meilleure image possible.
- [ ] Opposing pages with varying colouration or discolourations are filmed twice to ensure the best possible image / Les pages s'opposant ayant des colorations variables ou des décolorations sont filmées deux fois afin d'obtenir la meilleure image possible.

This item is filmed at the reduction ratio checked below /
Ce document est filmé au taux de réduction indiqué ci-dessous.

| 10x | | 12x | | 14x | | 16x | | 18x | | 20x | | 22x | | 24x | | 26x | | 28x | | 30x | | 32x |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | ✓ | | | | | | | | | |

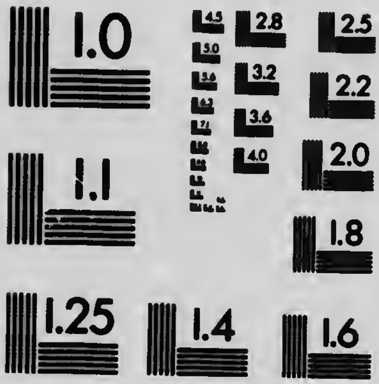

1
2
3


1
2
3


1
2
3
4
5
6

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)




APPLIED IMAGE Inc

1653 East Main Street
Rochester, New York 14609 USA
(716) 482 - 0300 - Phone
(716) 288 - 5989 - Fax

BULLETIN 153.] [FEBRUA[RY, 19]07

# Ontario Depart.nent of Agriculture

## ONTARIO AGRICULTURAL COLLEGE

---

# FERTILIZERS AND THEIR USE

By R. Harcourt, Professor of Chemistry.

---

## INTRODUCTION.

On our comparatively new lands, and in general farm practice where a judicious rotation of crops is followed, and where grain is fed on the farm and the manure properly cared for, it may not be necessary to use commercial fertilizers; but where the nature of the crops grown prevents rotation, and where very little farmyard manure is produced, they may be required. More and more each year it is found that the increased cost of production and the consequent need of producing maximum crops, and the growing demands of the larger towns and cities for garden and fruit products of high quality, are causing market gardeners and fruit growers to consider seriously the advisability of using some form of fertilizer. This has created a demand for information concerning these substances which it has not been easy to fill; for experience has shown that the farmer must posses a wide knowledge of plants, soils and the fertilizers themselves before he can properly use them.

To intelligently and economically use fertilizers, it is essential that the farmer understand the needs of the crops, their power to gather the essential plant food constituents from the soil, and the purpose of their growth, i.e., whether the object is to produce an immature plant for early market, or whether maturity is required. He must also know something about the available supply of plant food in the soil and the nature of the fertilizer being used. These fertilizers are expensive, and unless they are intelligently applied in conjunetion with very thorough cultivation they will not give their best results. They cannot take the place of cultivation; for they are food materials, and can only aid the growth of the plant as they are absorbed by the roots, and these cannot develop fully in a poorly cultivated soil.

Because of the wide variation in the amount of available plant food in soils, the differences in the needs of plants, and the necessity of the farmer gaining some definite information regarding the nature of the fertilizers he is using and the effect of these upon crops grown we strongly recommend those who contemplate using fertilizers to commence in a small way and prove for themselves whether they can or cannot use these substances with profit. The object of this bulletin is to point out some of the main features regarding plants, soils, and fertilizers, which should be known in order that the work may be done intelligently, and to indicate briefly how experimental plots may be arranged to show whether special fertilizing materials are or are not required.

---

## THE PLANT.

Most young plants start from a seed, which contains an embryo, or germ, that is extremely rich in albuminoids, fat, phosphates, and potash. The seed also contains a store of food, in the form of starch, fat, etc., intended to nourish the young plant until the roots and leaves are sufficiently developed to gather their own supplies. The future health and vigor of the plant will depend on: (1) the amount of food available to the tiny rootlets sent out by the young plant; (2) the temperature of the soil; (3) an abundance of sunshine, and (4) a sufficient supply of oxygen. The plant requires oxygen for respiration, and it gives off carbon dioxide as a result of the oxidation of its food, that is, it breathes; it gives off water from its leaves, or lungs, it assimilates food, and it even excretes waste material. In all this it is very similar to the animal. But it even goes further, and collects its food from the simple substances, such as carbon dioxide, and various soluble salts found in the soil, and from these builds up the complex sugars, starches, fat, and albuminoids which are essential for [illegible] ocesses of the plant and which are the only foods of the animal. [illegible] bject to improvement by selection and breeding, as is the an[illegible] unlike the animal, it is entirely dependent upon the supply [illegible] constituents within its reach, and it has no way of drawing attention to its wants, excepting as its appearance may make them known to the careful and trained observer. A clear conception of the fact that an infant plant, like the infant animal, requires warmth, air, sunshine, and an abundance of easily absorbed food, will greatly aid in understanding the conditions under which it will make the best growth.

### FOOD OF PLANTS.

The plant's food is derived from the atmosphere and from the soil. From the atmosphere it gathers carbon dioxide and oxygen, and some plants, through outside agencies, are able to collect nitrogen. Nearly fifty per cent. of the dry matter of a plant is made up of carbon which is entirely derived from the carbon dioxide of the air. Although this compound forms but 3 or 4 parts in 10,000 parts of the atmosphere, the quantity is sufficient, owing to the wind continually bringing fresh supplies to the leaves. Thus there is an abundance of air around the leaves of the plant, but, if the soil is not open and porous, there may not be enough in contact with the roots, for it is worthy of note that air in the soil in which crops are growing is as essential to the life of plants as air in the stable is to the animal. This ventilation of the soil is necessary to supply oxygen required in germination of seed, to permit the roots to live, for they, too, must breathe, and to supply this life-giving element to the millions of little organisms in the soil which are busy preparing soluble food for the plant. The ventilation of the soil is also required to supply free nitrogen for the use of nitrogen-fixing germs, and to remove the excess of carbon dioxide which is being continually set free in the soil.

From the soil the plant derives nitrogen, chiefly in the form of nitrates, the ash substances, and water. Fortunately, although ten elements are essential for the growth of the plant, there are only four that particularly interest the farmer, as the other six are usually found in abundance. These four are, nitrogen, potassium, phosphorus, and calcium. A continuous supply of all the essential elements of plant growth is absolutely necessary; for, if one constituent is absent, or present in an insufficient quantity, no matter what amount of the other nutrients may be available, the plant cannot be fully developed. Consequently, just as a chain is only as strong as its weakest link, so the crop-producing power of a soil is limited by the essential nutrient present in relatively the smallest quantity.

### Function of Plant Food Constituents.

In the absence of *nitrogen* the plant makes no appreciable growth. With only a limited supply, the plant commences to grow in a normal way, but as soon as the available nitrogen is used up, the lower and smaller leaves begin gradually to die down from the tips and all the plant's energy is centred in one or two leaves. Nitrogen is one of the main constituents of protein, which is possibly the most valuable part of a plant. It is also a constituent of chlorophyll, the green coloring matter of plants; hence with a limited supply of nitrogen, the leaves will have a sickly yellow color. Plants with large, well-developed leaves are not suffering for nitrogen. An abundance of this substance will produce a luxuriant growth of leaf and stem, but it will retard maturity, and, with cereals, will frequently cause the crop to "lodge." Therefore, when crops, such as cereals, tomatoes, potatoes, etc., are to be matured, an over supply of nitrogen is injurious; but with crops, such as lettuce, cabbage, etc., which are harvested in the green condition, an abundance of nitrogen will, other fertilizing constituents being present, tend to produce a strong vigorous growth, and give crispness or quality to these crops.

*Potassium*, or potash, as it is commonly called, is one of the most important and least variable of all the elements of the ash of plants. It is quite evenly distributed throughout the leaves, stem, and seed, and generally occurs in the entire plant in the largest proportion of any of the essential ash constituents. The function of potassium is apparently to aid in the production and transportation of the carbohydrates. The flavor and color of fruits is generally credited to potassium. In fact, this element seems to supplement the action of nitrogen by filling out the framework established by the latter. Potash with nitrogen is always an important fertilizer with special crops where the object is to produce sugar, starch—as with sugar be ts and potatoes. It is also apparently essential for the formation of protein, and, thus, indirectly, aids in the formation of all organic matter.

*Phosphorus*, in the form of phosphates, is found in all parts of the plant, but tends to accumulate in the upper parts of the stem and leaves, and particularly in the seed. Its function is apparently to aid in the production and transportation of the protein. It also seems to aid the assimilation of the other plant food elements. An insufficient supply of phosphoric acid always results in a poorly developed plant, and particularly in a poor yield of shrunken grain. Nitrogen forces leaf and stem growth, and phosphoric acid hastens maturity.

*Calcium*, or lime, is a constituent of the stem rather than the seed, and seems to impart hardiness to the plant. It has been noticed that soils containing an abundance of lime usually produce well nourished crops that are capable of withstanding unfavorable climatic conditions, as drouth and early frosts, better than are crops not so well supplied with lime. The exact function of lime is not clearly understood, but it seems to aid in the construction of the cell walls. According to some authorities, its absence is felt in less time than either potassium or phosphorus. It is claimed that a supply of lime is just as essential to the plant in order that it may form cell walls from sugar and starch, as it is for the formation of bone in animals. It also has a very decided influence on the mechanical condition of t soil, and is a liberator of plant food, particularly potash, held in uble forms in the soil.

There can be little doubt that a proper balance in the supply of these four important plant nutrients has a very decided influence on the nature of the plant produced. Each has its own particular work to do, and the absence or deficiency of any one of them will cause the death or the incomplete development of the plant. Moreover, they are absorbed during the early stages of growth; for a cereal crop contains at the time of full bloom all the nitrogen and potash which is found in the mature plant; the assimilation of phosphoric acid continues somewhat later. It is thus plain that crops require a good supply of these important constituents of plant growth in a readily available form if they are to make a proper development.

### Differences in Food Requirements.

Again, plants, like animals, differ very much in their requirements and in their ability to secure that which they need. Cereal crops contain much less nitrogen than legumes, but they have more difficulty in securing it. The autumn sown cereals have both deeper roots and longer period of growth than those sown in the spring, and consequently are better able to supply themselves with the necessary ash constituents. The spring tillage for barley, oats, and garden crops aids nitrification in the soil, therefore these crops have less difficulty in securing nitrogen. Barley, however, has a very short period of growth and is shallow rooted and cannot rustle for its food to the same extent as oats. Corn and the root crops are not only spring sown, but have a much longer period of growth than the cereals, and will thus have command of the nitrates produced during the whole summer. They have fairly good root development, but may not always secure all the potash and phosphoric acid required for the production of a full crop.

The striking characteristic of all the legumes is the large amount of nitrogen, potash, and lime found in them. However, although they contain fully twice as much nitrogen as the cereals, because of the power they possess of making use of the free nitrogen of the atmosphere, they have comparatively little difficulty in securing the required amount. On the other hand, they have difficulty in collecting potash. Consequently, it may sometimes happen that legumes suffer for want of this constituent on the same soil that cereals would find an abundance.

It will thus be seen that plants differ widely in composition, range of root, period of growth, and in their ability to gather that which they need from the soil. These are facts which a farmer should be familiar with in order that he may intelligently manure the soil and plan the rotation of crops he wishes to follow in a manner that will give the best possible results.

---

## THE SOIL.

But a knowledge of the plant and its requirements alone is not sufficient. It is very important that the farmer should know something about the constituents of the soil and the manner in which they may be brought into solution.

Soils are formed from rock by the prolonged action of water, frost, and air, combined with that of vegetable and animal life and their products. It is not necessary to go into details regarding the action of these various agencies. It is sufficient to point out that through their combined action, extending over thousands of years, the rocks have been broken down and their materials more or less separated by water into gravelly, sandy and clayey soils, and all the mixtures of these so commonly found throughout the Province. In these soils there is practically all the potash and phosphoric acid that was present in the original rocks. They are differently distributed, as, for instance, clays are richer in potash than sands; but the rocks are the sole source of the natural supply of these and all the other ash constituents essential for the growth of plants.

Nitrogen, on the other hand, is derived from the air and is incorporated into the soil largely by means of plants. Consequently, the natural richness of a soil in nitrogen is almost entirely dependent upon the amount of decaying organic matter present. Through careless cultivation, this original supply of nitrogen may be depleted; or by growing plants, particularly legumes, the nitrogen gatherers, it may be increased. There is an almost unlimited supply of nitrogen in the atmosphere and man has been given the means of gathering this and incorporating it in the land. As a result, the amount of this element in the soil, more than any other plant food constituent, is within the control of the farmer. Moreover, the addition of organic matter to a soil has a very much wider bearing than the simple addition of nitrogen; for, in its decay the vegetable acids and the carbon dioxide formed tend to bring the insoluble potash and phosphoric acid into an available form. Humus, which has such a wonderful effect on the mechanical condition of the soil, and which so increases its water-holding capacity, is also a product of the decay of organic matter. In fact, the presence of an abundance of decaying organic matter is practically indispensable. It is the source of nitrogen; the acids liberated in its decay make available the important ash materials which would otherwise be useless; it warms the soil; increases its capacity to hold water needed to dissolve the plant food; and improves its physical condition. Without the presence of organic matter and the associated germ life and the proper conditions for their action, a soil cannot produce its best results, no matter how rich it may be in all the essential constituents of plant growth. In one sense it may be correct to speak of a soil as a reservoir of plant food, to be drawn on for the growth of successive crops, but it is equally correct to regard it as a busy, complex manufacturing establishment in which all the various parts must work together under proper conditions to bring the store of plant food into a form available to plants. To bring this about is the object of cultivation.

### Losses of Plant Food by Leaching.

But these combined agencies, while beneficial, are destructive unless means are taken to prevent loss by drainage. They tend to bring nitrogen, lime, magnesia, potash, etc., into a soluble form, which, unless taken up by plants, is lost in the drainage water. As proof of this, we have the familiar fact that water taken from underground drains or from wells is "hard" because of the lime which it holds in solution. Consequently, a surface soil is generally poorer in lime, and frequently in potash, than the subsoil. The complete impoverishment of the soil is prevented by the presence of crtain constituents which combine chemically with the liberated plant food substances, and by the conservative action of vegetation. The plant is continually collecting from the soil and subsoil dissolved or easily soluble matter, storing these in its tissues, and at its death, leaving them in the surface soil. But even with the best of management there is some plant food leached from the soil.

However, according to a well known law, Nature allows nothing to be lost, and these leached out materials are, through various agencies, at least partially, made to accumulate in great beds of lime stone, phosphatic rock and potash salts. It is these accumulations of past ages that are to-day furnishing the main constituents of fertilizers. Who knows but what the plant food which is being annually leached from our fields will come into use in future ages.

### Losses of Plant Food in Crops.

But the leaching away of plant food is not the only way in which these materials are lost from the soil. The vegetable and animal produce of the land are frequently consumed off the land which reared them. A partial return of the plant food thus taken from the soil is made by the application of farmyard manures, but the sale of vegetables, fruit, grain, animals, and animal products, the congregating of men in towns and cities, and the difficulty in employing sewage with profit; and the loss of fertilizing constituents from farmyard manure before it is applied to the land, all tend to make the return of the manurial constituents to the soil incomplete.

Some soils are naturally so rich in the elements of plant food that when the crops are properly rotated and "catch" crops used to economize this natural wealth of fertilizing constituents, it may be a long time before the soil needs special manures; but, if the land is naturally poor, or injudiciously cultivated, or if special crops of like nature have to be grown year after year on the same ground, it may soon need some extra manure.

On naturally poor soils it may be necessary to make a complete return of all the elements of plant food removed by crops; but in most soils there is an abundance of some one or more of these elements, and a partial manuring will consequently suffice. With intensive farming, where thorough cultivation is practised, a good system of rotation followed, where little grain is sold and some food is purchased in its place, and every care taken of the manure, the land may even gain in fertility. These, however, are not the conditions which exist with the gardener and fruit grower, and they must of necessity purchase manure of some kind

---

## FERTILIZERS.

For the purpose of the present discussion, fertilizers may be divided into two groups. First, those which do not furnish in themselves any needed plant food, but whose chief value depends upon the power they possess of changing the insoluble and unavailable potash and phosphoric acid, into available forms; and, second, those which furnish directly to the soil the more important plant food constituents. Among the common materials of the first class are gypsum, lime, and common salt.

## Indirect Fertilizers.

*Gypsum, or land-plaster,* is sulphate of calcium, and has a limited action. It does furnish calcium and some sulphur, which are both required in considerable quantities by such crops as clover and turnips; but its chief action is in aiding the process of nitrification, by which ammonia and the nitrogen of organic matter are converted into forms which are readily assimilated by the plant, and in liberating potash and other elements of plant food from insoluble forms of combination and making them available.

*Lime,* like gypsum, aids nitrification and liberates plant food from insoluble forms of combination; but it is more powerful in its action. Heavy clays, which are rich in insoluble forms of potash, and soils containing large quantities of humus, are those most benefited by lime. In reclaiming swamp lands, the acid humic matter of the peat is neutralized by the lime, and the conditions thus made suitable for the oxidation of the nitrogenous organic matter and the production of ammonia and nitrates. Lime has also a very beneficial influence on the physical condition of the soil.

*Common Salt* supplies no essential ingredient of plant food. The little value which it possesses is probably due to its action in the soil, where it helps to set free more important constituents, particularly potash.

It is important to bear in mind that these indirect fertilizers do not add plant food to the soil, but that their chief value lies in the fact that they liberate plant food from insoluble forms of combination. Hence, if crops are not growing on the land to make use of the liberated food, or if the soil has been over stimulated by a large and frequent application of lime, gypsum, or salt, loss of nitrogen, potash, and phosphoric acid will occur. Consequently, these stimulants should be used in moderation. On soils not acid in nature, one to one and a-half tons per acre of lime at intervals of five or six years would be a safe application.

## Direct Fertilizers.

Direct fertilizers contain forms of plant food which contribute directly to the growth of plants. Such materials may contain either nitrogen, potash, or phosphoric acid compounds, or any two, or all three of these forms of plant nutrients.

Nitrogen. The more important purely nitrogenous fertilizers are nitrate of soda, sulphate of ammonia, and dried blood. A new one, known as calcium cyanamide, made by heating calcium carbide in air from which oxygen has been removed, has very recently come into use. It is the first successful attempt at gathering nitrogen directly from the atmosphere and placing it in a commercial form on the market. Experiments made in Europe show it to be about equal in value to nitrate of soda, though a little slower in its action. Our own examination of this substance shows that it contains about 20 per cent. of nitrogen and that nitrification takes place somewhat slowly, the largest amount being available about the third week after application.

POTASH. The muriate of potash and sulphate of potash are the two most important manures containing the one constituent, potash. The former contains about 50 per cent. and the latter 53 per cent. of pure potash. In both forms the potash is soluble and immediately available as food to the plant. *Wood Ashes* are an important source of potash. They contain only about one-tenth the percentage amount found in the muriate and sulphate of potash, but they are one of our own natural sources of potash and should be most carefully looked after. The potash in wood ashes is soluble and in a good form of combination. The ashes also contain some phosphoric acid and a large amount of lime.

PHOSPHATES. The most important phosphatic fertilizers are the ground rock phosphates and the superphosphates, prepared from them. Thomas phosphate, bone meal, bone ash, bone black, meat scrap, tankage, fish refuse, cotton seed hulls, horn dust, etc., are materials which contain more than one plant nutrient and usually none of them in a very readily available form.

## HIGH-GRADE FERTILIZERS.

These fertilizers may be again divided into high-grade and low-grade materials. Nitrate of soda, sulphate of ammonia, and dried blood are, for example, standard or high-grade nitrogenous materials. They are so classified, because they are fairly constant in composition and furnish nitrogen in some constant and definite form, which will always act the same under like conditions. Further, they are richer in nitrogen than any other nitrogenous manures, and the element is immediately or quickly available to the plant. Ground rock phosphates differ in this respect from the above mentioned nitrogenous substances, because, in the raw state, the phosphoric acid, for which they are valued, though present in large quantities and quite constant and definite in its form of combination, is not available to plants. After it has been treated with sulphuric acid and converted into superphosphate, it is high-grade, owing to the fact that the phosphoric acid is now available.

The various German potash salts, such as muriate of potash, sulphate of potash, etc., are also high-grade, since the composition of each grade and kind is practically uniform in its content of potash, which will always act the same under all conditions, and since they are richer in potash than any other potassic compounds suitable for making fertilizers.

## Low-Grade Fertilizers.

The products which are included in the second class differ from the first, in that they not only vary in their composition, but the constituents contained in them do not show a uniform rate of availability. Different samples of bone derived from the same source, treated in the same way, and ground to the same degree of fineness, would be high-grade, but because these conditions differ, bone from various sources cannot be depended upon to act the same under similar climatic and soil conditions. The same is true of tankage; but, it varies also in the proportion of its two main constituents, nitrogen and phosphoric acid, and in the rate at which they become available to plants. In this class we must also place fish scrap, wood ashes, and all the miscellaneous substances that may be used in building up mixed or complete fertilizers.

## Guarantees.

It is, therefore, evident that mixed fertilizers manufactured from these two classes of raw material will differ in value; for, the nitrogen from nitrate of soda or dried blood will act quicker and is worth more than that from ground leather or horn. In the making of the ordinary complete fertilizers of commerce, in which nitrogenous, potassic, and phosphatic materials are all mixed together, it is impossible for the purchaser to judge of the nature of the materials used by the appearance, weight, or smell of the mixture. This fact is so well recognized that some years ago the Dominion Government enacted a law whereby it was made illegal for any manufacturer or importer of fertilizers to offer for sale any fertilizer at more than ten dollars per ton without first submitting a sample to the Minister of Inland Revenue. Along with the sample there must be a statement setting forth the nature of the materials which enter into its composition and the manufacurer's certificate of analysis of the fertilizer. The sample is submitted to the Chief Analyst for analysis and is preserved by the Department for the purpose of comparison with any samples of the fertilizer of that brand which may be collected during the next twelve months. If the fertilizer is put up in packages, every package must have the certificate of analysis placed upon it or attached to it; if it is sold in bulk, such certificate must be produced and a copy given to every purchaser. Every certificate or guarantee must also contain a statement of the nature of the materials entering into the composition of the fertilizer.

According to the provisions of the Fertilizer Act, the samples must be sent to the Inland Revenue Department in January of the year in which they are to be offered for sale. Immediately on the completion of the analysis, usually in March or April, the Department issues a bulletin giving the special name of the fertilizer, by whom manufactured, from what materials it was produced, composition as reported by manufacturers, and the results of the Government analysis. It also contains a column in which the relative values per 2,000 pounds of each fertilizer is given. These bulletins are available to any one sufficiently interested to write the Department for one.

In reporting the analysis* for 1906, the Chief Analyst writes as follows: "In studying the present tabulated statement there seems to be good grounds for believing that the number of fertilizers of low price is on the increase, and it would appear necessary to call the attention of the farmer to the consideration that the fertilizing constituents in these are likely to cost him more than in fertilizers of a higher grade. It costs as much to mix a ton of fertilizer containing say 300 pounds of plant food as it does one containing twice that quantity. The cost of packing, cartage and freight is the same per ton. It is evident, therefore, that the manufacturer is in a position to sell the fertilizing constituents of a high-grade fertilizer at cheaper rates per pound than those in brands of low grade. In other words, the higher the grade the cheaper can the plant food be bought. Farmers should therefore consider the advantages of purchasing only high-grade fertilizers. They should be also advised to avoid those brands which have less than 2 per cent. of ammonia or potash. These percentages are too low in cases where such ingredients are required, and where they are not needed it is useless to purchase them. It is waste of money to buy nitrogen or potash in fertilizers containing less than one per cent. of these ingredients."

## Calculation of the Value of Fertilizers.

As previously stated, the tabulated results in the fertilizer bulletins of the Inland Revenue Department includes a column showing the trade value of the various brands of fertilizers analyzed. These figures do not represent the agricultural value, which would be measured by the value of the increased crop produced by their use; because it is manifestly impossible to fix the value of any of the constituents that will be correct under the varying conditions of soil, crop, season, and method of use. What they are intended to show is what the farmer would have to pay the manufacturer for the constituents which are in the fertilizer before they are mixed. These trade values of each constituent are obtained by simply calculating the cost, using two factors—the wholesale price of the different materials containing them, and their average composition. To this cost is added a certain percentage to represent the cost of handling and distribution in small lots. Calculated in this way, Bulletin No. 118 of the Inland Revenue Department gives the following figures as the trade value of the fertilizing ingredients:

* Inland Revenue Department, Bulletin No. 118.

*Nitrogen*:

| | Cents per lb. |
|---|---|
| Nitrogen in salts of ammonia or in nitrates, as well as in compound fertilizers | 17 |
| Organic nitrogen in ground bone, fish, blood or tankage | 16 |

*Phosphoric acid*:

| | |
|---|---|
| Soluble in water | 6 |
| Soluble in 1 per cent. citric acid solution | 5½ |
| Insoluble as in Thomas' phosphate powder | 3½ |
| Insoluble as in ground rock phosphate and fertilizers generally | 1½ |

*Potash*:

| | |
|---|---|
| Potash in high-grade salts | 5 |

The value of these figures is that by their use and the percentage composition, or guarantee, the purchaser is able to calculate, at least, the approximate cost of the fertilizer and is thus not likely to be imposed upon. Voorhees, in his book on "Fertilizers," points out that there is a very decided lack of intelligent application of this information, and gives the following illustration of the fact that farmers do, in many cases, pay exorbitant prices for their fertilizer constituents, not because the manufacturer did not sell what he claimed to sell, but because the price charged by the dealer was far in excess of that warranted by the guarantee: "Two brands are offered, made up from the same kind and quality of materials. No. 1 is guaranteed to contain:

| | |
|---|---|
| Nitrogen | 1 per cent. |
| Phosphoric acid (available) | 6 " |
| Potash | 1 " |

and sells for $20 per ton; No. 2 is guaranteed to contain:

| | |
|---|---|
| Nitrogen | 4 per cent. |
| Phosphoric acid (available) | 8 " |
| Potash | 2 " |

and sells for $22 per ton. The farmer who buys on the ton basis, or is guided only by the ton price, will be induced to purchase the No. 1 brand, because by so doing he apparently saves $2 per ton. The one who studies the relation of guarantee to selling price will purchase the No. 2 brand, because he finds, from a simple calculation, that it furnishes the constituents at just one-half the cost per pound of the No. 1 brand, notwithstanding the higher ton price, which is shown by the following calculation:

No. 1.

| | | Lbs. per ton. | | Cts. per lb. | |
|---|---|---|---|---|---|
| Nitrogen | 1% x 20 = | 20 | at | 30 | $6.00 |
| Phosphoric acid (available) | 6% x 20 = | 20 | at | 10 | 12.00 |
| Potash | 1% x 20 = | 20 | at | 10 | 2.00 |
| | | | | | $20.00 |

No. 2.

| | | Lbs. per ton. | | Cts. per lb. | |
|---|---|---|---|---|---|
| Nitrogen | 4% x 20 = | 80 | at | 15 | $12.00 |
| Phosphoric acid (available) | 8% x 20 = | 160 | at | 5 | 8.00 |
| Potash | 2% x 20 = | 40 | at | 5 | 2.00 |
| | | | | | $22.00 |

In reality, the fertilizer at $22 per ton is cheaper than the one at $20 per ton.

| Cost per pound of constituents in: | No. 1. | No. 2. |
|---|---|---|
| Nitrogen | $0.30 | $0.15 |
| Phosphoric acid (available) | .10 | .05 |
| Potash | .10 | .05 |

This may seem an extreme case, but it is well within the facts, which may be ascertained by consulting the bulletins on fertilizer analyses, as published by the different States."

It will thus be seen that the Government in compelling the manufacturer and dealer to produce the guarantee at time of sale, does not wholly protect the farmer. He must be able to use the data given to ascertain which fertilizer will really give him the best value. Furthermore, sometimes the guarantees are rendered confusing to the purchaser, because of the way in which they are stated, and if he is going to buy intelligently he must endeavor to post himself as to the meaning of the different terms.

## Home-Mixing of Fertilizers.

Reference to the bulletins of the Dominion Inland Revenue Department shows that there are a great number of brands of fertilizers on the market which are specially recommended for certain crops. These mixtures may or may not suit the conditions of the soil and the needs of the crop. Unfortunately, the tendency is for the farmer to buy these mixtures, but as they understand the true principles of fertilization, the tendency will be to buy the simple substance, as nitrate of soda, muriate of potash, and superphosphate, or the Thomas phosphates, which are not so hard to understand, to make up the deficiency of the soil or to supply the needs of the crop. Or they may buy these high-grade materials of known quality and prepare their own mixtures.

It may often occur that home mixtures of fertilizers can be made which will better meet the requirement of the particular soils and crops under cultivation than any mixture that can be procured on the market. Reliable authorities have estimated that the charges of the manufacturers and dealers for mixing and bagging are, on the average, $8.50 per ton. It is evident that this, together with the extra freight on and cost of handling the make-weight substances commonly added, would leave a fair margin to pay for labor involved in making the mixtures at home. The offal from our pork-packing houses, if properly ground, could well be used as the basis of many of such mixtures. As it is, practically all of this valuable fertilizer is shipped out of the country, where it is ground, mixed with other substances, rebagged, and much of it finds its way back into this country under the name of many special brands of fertilizers.

### Application of Fertilizers.

As a rule, fertilizers must be looked upon as adjuncts to farmyard and green manures, and should be applied to make up some deficiency in the soil or to add some constituent specially needed by the crop grown. Consequently, in general farm practice on soils in good condition, one element may be all that is required, as, for instance, nitrogen for cereals and mangels, potassium for the legumes, and phosphorus for turnips. With the gardener and fruit grower more than one constituent may be required. But he must not lose sight of the fact that he cannot get good results without an abundance of humus in the soil, and if it cannot be supplied from farm manures, it must be obtained from crops, preferably legumes, grown to plow down.

Space will not allow a full discussion of the characteristic fertilizers for each crop. Some reference has been made to the ability of the ordinary farm crops to absorb food, and, in general, it may be stated that the ones most likely to give remunerative returns for the fertilizers applied are those which require a great deal of labor in their cultivation. A maximum crop of mangels or turnips does not require more labor in cultivation than half a crop, and, frequently, if all the other conditions are right, a dressing of one or two hundred pounds of nitrate of soda to the former, or two to four hundred pounds of superphosphate to the latter, will make a wonderful difference in the yield.

With reference to the crops of the market gardener and fruit grower, it may be stated that quality is often as important a point as quantity.

Quality depends upon, or is measured by, both appearance and palatibility. Palatibility is determined by the succulence and sweetness of the vegetable, or its freedom from bitterness, stringiness, and other undesirable characteristics which frequently exist, and which can be largely eliminated by providing an abundance of food for a continuous and rapid development of the plant. Any delay in the growth of a radish or of lettuce is largely responsible for the sharp taste or pungent flavor of the former, and the bitterness and toughened fibre of the latter. A reasonable excess of all the fertilizer constituents is required for all garden crops, and where succulency is specially required, nitrogen and potash should predominate.

### How to Experiment with Fertilizers.

Every man must study his own soil and crop conditions. Experiment stations may experiment from now until the end of time and still not be able to answer the question for the individual. Principles can be established, the needs of different crops can be learned, the composition of fertilizers can be determined, chemical and physical analyses may show wherein soils differ; but when it comes to the question of the profitable use of the fertilizers, each farm, each field, must answer for itself. That is, careful, intelligent, and accurate experiments must be carried on by every farmer, gardener, and orchardist who wishes to settle this point.

In all fertilizer experimental work it is important that the land used be as uniform in soil condition and previous manuring and cropping as can be procured. The size of the plots may vary according to the nature of the crop from two square rods to one-tenth to one-third of an acre, or larger if desired. The larger plots have some advantages, but, the smaller the plots the more likely they are to be of uniform soil, and the labor involved in harvesting and weighing the crop is less. A space should be left between the plots to prevent the roots of the plants in the border line drawing food from both plots.

The following simple plan for experimenting can be carried out by any farmer without difficulty, and enables him to find out if the land is in need of plant food. The plan as it is can be adopted for vegetables, fruits, and most field crops, except legumes. The amount of fertilizers given are for an acre, and can be reduced according to the size of the plot.

Plot No. I.—Check. No fertilizer.
" II.—600 pounds of superphosphate.
120 " muriate of potash.
180 " nitrate of soda.
" III.—600 " superphosphate.
180 " nitrate of soda.

In this experiment, plot No. I. will show what the land without any fertilizer will produce; plot No. II. indicates what effect an average complete fertilizer will have, and plot No. III. shows the effect of nitrogen and phosphoric acid, and brings out the influence potash has had on the crop.

A simple form of experiment to study the soil deficiencies in respect to a single element of plant food, and the relative needs of the different crops for the various constituents, is as follows:

Plot No. I.—Check. No fertilizer.
" II.—160 pounds of nitrate of soda.
" III.—160 " muriate of potash.
" IV.—320 " superphosphate.

Or, if it is wished, the experiment may be made more complicated, as follows:

Plot No. I.—Check. No fertilizer.
" II.—160 pounds of nitrate of soda.
" III.—160 " muriate of potash.
" IV.—320 " superphosphate.
" V.—Check. No fertilizer.
" VI.—160 pounds nitrate of soda.
320 " superphosphate.
" VII.—160 " nitrate of soda.
160 " muriate of potash.
" VIII.—320 " superphosphate.
160 " muriate of potash.
" IX.—160 " nitrate of soda.
160 " muriate of potash.
320 " superphosphate.
" X.—Check. No fertilizer.

The amount of the fertilizers given are, in every case for an acre, but they are not intended to represent the quantities of these materials which should be used for various crops. That point will be arrived at as a result of the experiments. The application of the potash and superphosphate should be made broadcast before planting, preferably some weeks before. The nitrate is very soluble, and is easily leached from the soil, consequently, it is best applied in two or three applications, one at time of sowing seed, and the other two at intervals of three or four weeks. In every case, the fertilizers should be evenly distributed over the ground. The above mentioned quantities provide for one pound or multiple thereof per square rod.

Careful notes should be made on the increased cost of production, the appearance and quality of the crop, and the weight of the products of the different plots should be determined, and the whole data used as a basis of comparison. As interest in the work increases, further experiments may be made with different quantities of these materials and with other fertilizers.

In these fertilizer experiments it may also be well to introduce lime into one or two of the plots, in order to determine whether this substance is needed either to correct acidity or to make other useful compounds available. Further, it would be good practice to include in the number of plots indicated one or two in which the cultivation of the soil was made more perfect, the object being to see whether the need is for more plant food or better cultivation.

All these experiments have a much wider scope than the simple finding out of the deficiencies of the soil. They are educative, as they encourage close observation and exact methods of work, and give the experimenter an opportunity to familiarize himself with the materials used as fertilizers.