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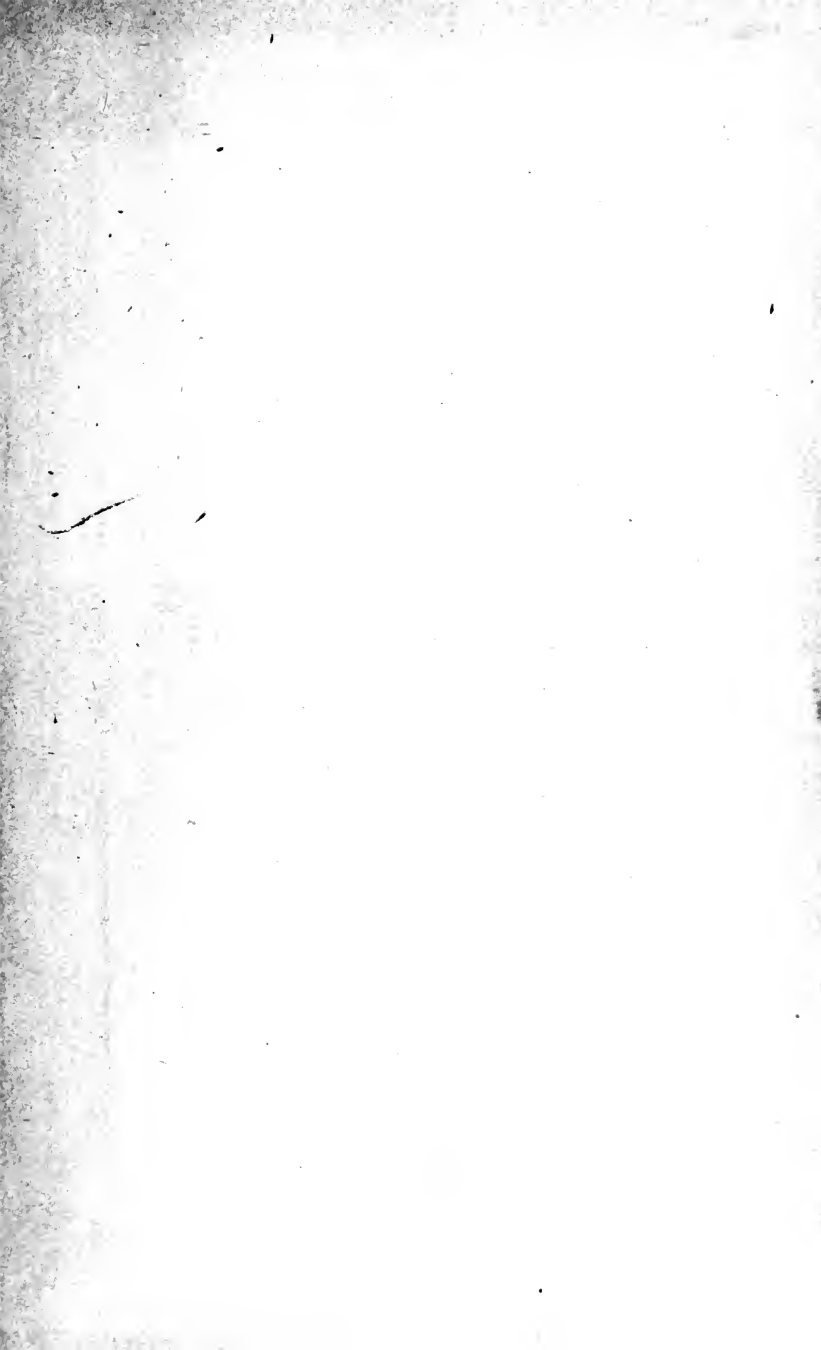
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# *Practical Farm Chemistry.*

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A HANDBOOK OF  
PROFITABLE CROP FEEDING.

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PART I.—The Raw Materials of Plant Food.

PART II.—The Available Sources of Supply.

PART III.—Principles of Economic Application, or  
Manuring for Money.

---

BY

T. GREINER, LA SALLE, N. Y.

Author "HOW TO MAKE THE GARDEN PAY," "THE NEW  
ONION CULTURE," Etc.

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## INTRODUCTION.

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**I**N YEARS gone by the farmer had little use for agricultural chemistry. The virgin soil was so well supplied with all the elements needed for plant nutrition that the only thing for him to do was to plant, and till, and reap a bountiful harvest.

Times and conditions have changed. The land does not respond any more quite so promptly to merely scratching its back with plow and harrow. It has grown weary and hungry. It now looks for food, and coaxing, and petting, before it can be made to smile with flowers, fruits, vegetables and grains.

The farming of our fathers was based upon the almost unlimited generosity of nature, and the original wealth of the soil. The farming of the present day is changing more and more to a process of manufacturing crops out of raw materials largely supplied by man. The soil only serves us as a medium and implement of manufacture.

We find ourselves burdened with duties not im-

posed upon our fathers. The foremost and most formidable task which confronts us, is that of finding and providing the raw materials required for the manufacture of the crops which we wish to produce, and this, too, at prices that will leave us a fair profit.

These raw materials are expensive. If we purchase them carelessly, and apply them indiscriminately or injudiciously, we are apt to find ourselves the losers in the transaction. Here agricultural chemistry comes to our aid in solving many of the problems concerning the needs of our crops, the nature and value of the raw materials, and their economical application.

While every good farmer should familiarize himself with these cardinal points, he has no need to be a chemist. He looks at this science from the standpoint of the practical soil tiller, not from that of the professional man of retorts and the laboratory.

I have studied the problems here involved from this same practical point of view; yet what I do not know about chemistry would fill large volumes. Such a confession at the very beginning is needed, not only to shield myself against the assumption of undue responsibility, but also to serve as a warning for the reader against extravagant expectations.

The professional chemist rarely knows how to grow a single farm crop successfully and profitably; yet, the success of modern farming depends in a large measure on the proper application of knowledge developed by the experiments in the laboratory. The chemist can tell us the exact quantities of the various elements which constitute a plant, or a grain, or a fruit. He can also tell us how much of each of these elements or substances is contained

in a cubic foot of soil. But we must not imagine that in order to be able to secure a certain yield of any crop, it would only be necessary to ascertain by analysis the exact amount of plant food in the soil, and to supply the deficiency of the substances needed to bring the aggregate amount in the soil up to that required in the production of the intended crop. The subtle ways and agencies of nature, the action of soil and life forces and forms in it baffle the skill of the chemist, and force him to confess that he has reached the end of his wisdom.

Where chemistry fails to acquaint us with the causes, from which we might expect certain results, the experimenter must step in, observe the results, and try to ascertain the causes in his way. The chemist's analysis and the farmer's tests—these are indispensable requisites of modern husbandry, and the corner stones of success in profitable crop feeding. No farmer can select and purchase fertilizers with proper regard to economy and fitness, or apply manures intelligently, unless he has some understanding of the principles that govern plant growth, of the various elements of plant food, their action and their values.

The study of these problems has been a source of much satisfaction and profit to me. I believe it would also be so to other farmers and farmers' boys, who in this era of low prices and "agricultural depression" are trying hard to learn how, by the use of improved methods, farming may be made to yield fair returns for the labor and capital invested. I am sure the task will be materially lightened by a thorough understanding of the principles here involved.

These considerations have lead me to attempt,

in the following pages, an explanation of the truths as they were revealed to me, and this in simple language that all can understand. I have tried to treat the matter in such a way that it will interest and instruct the young men, and help them to become successful farmers.

THE AUTHOR.

LA SALLE, N. Y., SPRING, 1891.

PART I.

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THE RAW MATERIALS  
OF  
PLANT FOOD.





# FIRST CHAPTER.

---

## MATTER AND ITS FORMS.

---

**T**HE first question that the inquisitive student is most likely to ask, concerns the *composition* of matter. Of what substances are the plants, the animals and all other earthly things, live or dead, composed? What is water, what earth, what rock, what air?

Suppose we dip up a quart of liquid manure in the barn-yard and empty it upon the ground in the garden. It soaks in and disappears from view, but its every part remains in existence all the same. While passing downward through the soil, some of the ingredients that are held in solution, forming with the water a most intimate mechanical mixture, and giving it color, are filtered out and retained in the soil. The liquid that reaches the subsoil is comparatively free from the foreign substances that were held only in solution, and now consists of little more than pure water. This may pass into underground veins, and bubble up again, far remote, in a spring or well.

**Changes of  
Form:**

Exposed to frost, it will turn into ice, and assume the solid form. We may put a piece of ice into a vessel on a hot stove. It will melt and form water; and this we can boil away, until the vessel is empty. Still we have not annihilated the water by driving it out of the vessel. In a new form, that of steam, it is floating in the air, occupying a space 1,700 times as large as it did in the form of water. In time, this steam or gaseous water again condenses and becomes liquid, and under still lower temperature, turns to ice.

Here we have observed a number of changes, but all these were merely changes of form or condition, not of chemical composition. Water changes its forms on slight provocation, but whether gas, liquid or solid, it is chemically the same thing—water.

There are other changes, however, more violent, more thorough, and often more permanent than those just mentioned. These are chemical changes, and I can give no better illustration than by comparing them to the changes which the youngster makes with his building blocks. He puts up a structure of some sort; then tears it down again, and uses the same material, re-arranged, in the construction of a building perhaps altogether different.

Water is not a simple substance, or element, as supposed by the old school of philosophers who named water, air, earth and fire as the four elementary bodies. By passing an electric current through it, and by various other means, we have it in our

**Chemical  
Changes.**

power to decompose a quantity of water; that is, sever the intimate connection between its two constituents—hydrogen and oxygen. These are two gaseous bodies which occupy still more room than steam, so that a few

drops of water, separated into their two elements, would give us two quarts of hydrogen and one quart of oxygen. They may be caught and kept confined in a tight glass vessel in this form as long as you please. Without outside impulse they will not combine chemically, but remain a mixture of gases. When ignited, however, the two substances rush into each other's arms as in a sudden passion. We have a violent explosion, a chemical combination, and as a result, two quarts of steam, which when condensed, again appears as the few drops of water with which we started.

In oxygen and hydrogen we have two elementary bodies, or simple substances which cannot be further separated into other substances. Modern chemistry knows between sixty and seventy such elements; and all existing matter, whether organic (matter which has performed functions of life, or is the result of such functions) or inorganic (anything which is and has been without life, and is not the result of functions of life), is made up of these elements, in various proportions, and in all sorts of combinations, which give us the diversified and innumerable forms of matter.

The farmer is most deeply interested in a knowledge of the elements which go to make up vegetable and animal products, and it is a wonderful fact, that of those nearly seventy elementary bodies, only twelve or fourteen are of sufficient importance to deserve the farmer's consideration, and that the

**The Elements.** great bulk of all agricultural products consists of the four elements, carbon, hydrogen, oxygen and nitrogen. These are the organic constituents of plants; all others are inorganic elements, and consist chiefly of calcium,

chlorine, magnesium, phosphorus, potassium, silicon, sodium and sulphur. Here we have all the raw materials that enter into the structure of plants and animals. The husbandman, as manufacturer of grain, fruits, etc., will find a thorough acquaintance not only with the machinery of nature which furnishes him the motive power, but also with the various raw materials of which he has to construct his products, fully as indispensable to highest success as the acquaintance with the various grades of saccharine substances, with the dye stuffs and flavoring extracts, is for the manufacturer of candy. He must learn their nature, peculiarities and modes of operation.



## SECOND CHAPTER.

### THE ORGANIC ELEMENTS.

**O**F THE four elements which constitute the bulk of vegetable substances, and which are torn away from this combination and allowed to escape into the air by exposure to heat (rapid combustion, or burning), carbon deserves to be named first, as it forms nearly one-half, by weight, of all the dry substance of our farm crops. In charcoal we have the most common and best known, though an impure form of carbon. Other organic forms of this element are soot, lamp-black, etc., and in an inorganic condition it appears in the diamond, which is pure carbon, in graphite, petroleum, etc.

Oxygen forms about one-third, by weight, of the dry substance of vegetable matter. It is a most remarkable, ever-present, gaseous body, responsible for the great changes that occur, and especially powerful in destroying. We may call it omnivorous (all devouring), as it is always ready to pounce upon and combine with other substances, tearing them away from other affiliations, and thus ever changing their forms and conditions. It has a particular appetite for carbon and other combustible substances, and when once

given a good opportunity by exposure to heat, will seize and devour them in fiery embrace. This process in everyday life is termed burning.

Oxygen also destroys vegetable and other substances in a slower way, under a rise of temperature so slight that it generally escapes our notice. This slow combustion (oxidation, burning) is commonly called decaying, rotting or rusting. But whether rapid with fire and flame, or so slow as to be hardly perceptible, this decomposition is the result of the same element and of the same process—a chemical union with oxygen.

Hydrogen—"trifles lighter than air," in fact, the lightest known substance—forms only a little more than one twentieth part of the dry substance of plants. This gas, like oxygen and nitrogen, has

**Hydrogen.** neither taste, smell nor color, but unlike them, is very inflammable. Burnt hydrogen (hydrogen combined with oxygen in the proportion of one pound of the former to eight pounds of the latter) is the common liquid we call water. Combined with carbon we find this gas in the common coal gas, used for illuminating purposes, in petroleum, etc.

Nitrogen, although forming four fifths of the atmosphere, where it exists in *mixture* (not in combination) with oxygen, and entering still more

**Nitrogen.** lightly into the composition of plant substance than does hydrogen, deserves the study and attention of the farmer even more than the three elements already named, for it is not available as plant food in its simple form, and not so easily or cheaply obtained in the desired combinations as other elements of plant food.

## THIRD CHAPTER.

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### CARBON, ITS NATURE AND ACTION.

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THE action and influence of these various elementary bodies upon each other, and upon other substances, are a fit subject for further consideration. In charcoal, as already said, we have a simple but impure form of carbon. From the fact that carbon forms nearly one-half, by weight, of the dry matter of all plant products, it would be but natural to suppose that charcoal would be one of the most effective plant foods, and the most important ingredient in fertilizers. This, however, is not the case. Carbon is entirely insoluble in water. Air, under common temperature, does not effect it.

We might grind charcoal ever so fine, and put it ever so close to the roots of plants; these latter could not possibly take it up into their circulation. Now let us take this charcoal (or dry wood, or any other substance containing carbon) and put it upon live coals in the stove. The draft in front admits air freely, and the oxygen of this air rushes upon the carbon and devours it; that is, combines chemically with it, forming the gaseous compound "carbonic acid." This escapes through the chimney, and is diffused through the atmosphere. It is a colorless gas with

**Carbonic  
Acid.**

an acid taste and smell, and considerably heavier than common air.

Now, while thousands of stoves and furnaces and lamps are pumping carbonic acid into the air without cessation; while a stream of the same gas issues from every pair of lungs (the process of life is only a combustion of carbonaceous matter); while decaying vegetable and animal substances also give forth quantities of the gas; the atmosphere, which naturally contains one part of it in each 2,500 parts of the oxygen-nitrogen mixture called air, would soon become overcharged with it, and unfit to sustain animal and even plant life, if no provision were made by nature for just this emergency. But plants and trees must have carbon, and are hungry for it.

**Plants Absorbing  
Carbonic Acid.**

So they set their traps all over the land to catch this substance as it is floating in the air. The leaves and even the stems of plants are full of pores, and through these the carbonic acid gas is absorbed and brought into circulation in the sap, where it undergoes chemical changes, and is manufactured into starch, sugar, plant fibre, etc., all of which substances are largely or chiefly composed of carbon. The carbon is retained, while the oxygen is again exhaled; and the right proportion between the gases—the proper balance in the atmosphere—is thus maintained.

While plants and trees thus obtain a large portion of their carbon from the vast and unceasingly renewed stores in the atmosphere, the roots also absorb more or less of it from the soil. Carbon, in its simple or elementary form, is insoluble in water, and oxygen is only soluble to a very small extent. Their compound, “carbonic acid,” however, dis-



solves very readily in water. By absorption from the atmosphere, by the decay of organic substances in the soil, etc., it finds its way into the soil water, and with it into the plant. Besides this direct usefulness as plant food, it has the indirect value of giving to the water which holds it in solution an increased power of dissolving other mineral substances, and of those making them available for plant food.

Although it is true that charcoal, being insoluble in water, can not directly enter into the circulation of plant sap, and that plants can depend upon the atmosphere for almost the whole of their carbon supply, if necessary; yet the application of pulverized charcoal, or other finely-divided carbon in its elementary form, shows often remarkable effects upon plant growth. This is to be explained otherwise than on the theory that the elementary carbon can be utilized as plant food. Charcoal might be regarded as the skeleton of the wood from which it was prepared. A large portion of the substance of the wood has been driven off by heat, but the form,

the structure, still remains, and consequently the charcoal skeleton is exceedingly porous. Like other porous substances, it possesses the power of absorbing and condensing gases. Hop growers know what a large bulk of dried hops can be condensed into the space of a bale by means of a good hop-press; but a hop-press is next to powerless when you compare it with charcoal. This substance will absorb and condense in itself ninety times its own bulk of ammonia, thirty-five times its bulk of carbonic acid, and other gases proportionately. It catches plant foods, and brings and holds them for

**Charcoal  
Absorbing Gases.**

the use of vegetation. The precious but volatile ammonia is not only held, but brought in immediate contact with oxygen, all condensed in the charcoal pores, and changed into the stable nitric acid, etc. This power of absorbing and condensing gases gives charcoal, also, its great value as a disinfectant and deodorizer.

New soils generally have an abundance of carbonaceous matter—the decomposed remains of vegetable productions, leaf mould, humus, peat, vegetable mould—as this always accumulates in forests, pastures and swamps. Various acids, such as ulmic, humic, etc., contained in these substances, are merely carbonic acid yet in process of preparation, or unfinished. Carbon of the vegetable matter combines with a little oxygen and forms ulmic acid; this combines with a little more oxygen and forms humic acid; this again combines with more oxygen, and forms geic acid, and so on through several more steps until the final result, carbonic acid is reached. All these combinations of carbon with oxygen, under certain conditions, can serve as food for plants, while the constant absorption of oxygen also favors the production of nitrogen compounds.

By constant cropping, without application of bulky manures, the carbonaceous matter in the soil becomes exhausted. The process of oxidation, or decay, stops, since there is no material to work on.

**Carbon Needed  
in the Soil.**

The production of carbonic acid ceases, and with it the supply of a most important plant food to the roots. The soil water loses part of its solvent power. The conversion of nitrogenous matter into ammonia and nitric acid (in which forms alone nitrogen can be taken up by plants) also comes to an end. In

short, the soil has become dead. It hardens, closes its pores, and no further produces profitable crops. These, indeed, are dire results of the exhaustion of carbonaceous matter.

Nature has a remedy, when man does not interfere. Weeds, shrubs, trees spring up, catch the carbon floating in the air, and by their decay deposit carbonaceous matter on top of the soil (leaf mould, humus), and thus in the course of many years furnish a new supply. The natural process of recuperation is a lengthy and tedious one. The soil tiller can hasten it, and restore life and activity to the soil by the reintroduction of abundant carbonaceous matter; in other words, by application of stable manure or peaty substances, or by plowing under crops, such as clover, southern black peas (cow beans), lupines, weeds, etc.

On the whole I think that carbon occupies a position of greater importance in the economy of plant growth and profitable plant feeding than is assigned to it by a majority of farm writers, of high as well as low degree, or than might be inferred from the fact that no quotable value is conceded to it, or that it is entirely left out in the computation of commercial values of manures. This subject will be taken up again further on; for it is plain that satisfactory cropping cannot usually be continued for any length of time, unless the natural condition of the soil is maintained by restoration of the consumed vegetable matter through one or the other of the processes named.

## FOURTH CHAPTER.

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### OXYGEN AND HOW IT ACTS.

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**I**N THE foregoing chapter we have seen the great influence wielded by the elementary body, oxygen upon carbon. It transformed the solid substance into the gaseous and soluble carbonic acid, thus fitting the carbon for plant food. We have also observed how the oxygen unites with the gaseous, combustible hydrogen, and condenses with it to the common liquid, water.

This oxygen is a wonderful element, combining with every other substance, in violent or slow combustion, forming gaseous compounds with some substances (as carbonic acid with carbon), liquids with others (as water with hydrogen), and solids with still others (as caustic or fresh-burned lime with the metal calcium). As a product of its combination with hydrogen, we have the harmless compound, water; with carbon, the poisonous gas, carbonic acid; with calcium, the corrosive alkali, "caustic lime." As products of its combination with other substances we have potash, magnesia, silica, sulphuric acid, phosphoric acid, etc. Some of these are alkalies, others acids. The former have an acrid taste, the latter a sour taste, and all are corrosive, until neutralized

**Oxygen  
Compounds.**

by combinations between an alkali on one side and an acid on the other. In short, the all-pervading oxygen is ever ready to take hold of anything that comes along, changing it in form and nature.

Combustion—the burning and apparent destruction of any substance—as already stated, is nothing more than its chemical combination with oxygen. Close the draft of a stove so tight that no more air is admitted to the burning material, and burning will cease. Oxygen is also indispensable for respiration, as this is merely a burning process, or a combination of oxygen with carbon, by which animal heat is generated, much in the same (though less violent) way as heat in a furnace. Shut off the supply of oxygen to the lungs, and the animal fire, called “life,” comes to a sudden stop. This oxygen is the most common substance on earth. Eight ninths of the water and a large share of the rocks and minerals consist of oxygen in chemical combination. In the atmosphere we have it combined, merely in mixture with nitrogen, and the latter seems to serve the purpose of a dilutant, simply. Clear alcohol, when used as a beverage, would soon kill the hardest drinker; but many persons who indulge in that article, largely diluted, (although I would not dare to recommend the practice) live to a good old age. So would clear oxygen stimulate the life forces to excessively hasty action, and hurry up the change of tissue much faster than nutrition could restore it, thus crowding a number of years of one’s life into one. A great dilution is absolutely necessary, and the diluting medium, nitrogen, forms four fifths of the atmosphere.

## FIFTH CHAPTER.

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### NITROGEN, ITS NATURE AND EFFECT.

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“SO NEAR and yet so far”—that is what the soil worker might truly say of nitrogen, which to him is the most important, as it is the most expensive to procure, of all fertilizing substances. For while it exists in vast and unlimited quantities, surrounding our whole world in a layer many miles in thickness, and forming such a large part of our atmosphere that tons and tons of it are resting upon each acre of ground, it is at the same time exceedingly shy and modest—a blushing, bashful maiden among the elements. It can only be won after hard wooing, and it finds only few acceptable suitors among its “set.” It refuses to be absorbed into plant structure in its single state, except in a very small way when dissolved in water (this absorbs only a little more than one per cent of its bulk), and can be induced to enter plant tissue only after having formed a chemical union with a congenial mate or element. While the farmer need not worry about a source of supply, so far as oxygen and hydrogen are concerned, and usually but little so far as carbon

**Elementary  
Nitrogen  
Not Available.**

is concerned, since water and carbonic acid, ever-present, furnish them in great abundance, and hold them in constant readiness for the use of the plants, the question, how to get hold of nitrogen and make it available for our crops, is a serious one.

Nitrogen forms about one sixth of all animal tissue, and enters largely into the composition of plants. Under the pressure of natural agencies it enters chemical unions with hydrogen and oxygen, and forms various compounds.

When we open a bottle containing the liquid sold by grocers and druggists under the name "Household Ammonia," a gas escapes which has a most pungent odor, and an acrid burning taste. This is ammonia, a chemical compound of hydrogen and nitrogen, three parts by weight of the former to fourteen of the latter. Water dissolves or absorbs seven or eight hundred times its bulk of it, and thus charged, is put up in these bottles and sold for cleaning purposes.

This nitrogeous gas, ammonia, is evolved from all decaying animal substances, dead bodies, solid manure, and urine, and it is also formed during the decay of vegetable substances in the soil. In the morning after a cold night, when stable doors have been kept closed pretty tight, a pungent odor greets us on entering horse and cow stables. This informs us of the presence of ammonia. The gas is very volatile, and easily escapes into the air, where it may be decomposed, losing again its available form, or to be absorbed by moisture and carried down to the soil by rains or snows in equal distribution over fields and woods of good and poor cultivators of the soil, and without inquiring where most needed.

Ammonia being an alkali, readily combines with

acids, and this gives us a clue how to catch and hold it for use just where needed. It is especially fond of sulphuric acid, and whenever the two meet, they at once enter a close (chemical) union, forming the salt "sulphate of ammonia."

This is the reason, and a good one, why the advice is so often given to scatter sulphate of lime (gypsum or plaster), sulphate of iron (green copperas), kainit, or other compounds of sulphuric acid, over fermenting manure

**Ammonia  
Catchers.**

heaps and in stables. If followed, it will result in saving most of the precious but fleeting gas ammonia, and holding it fast, for use as plant food, in the form of a solid salt, soluble in water, but not volatile. The ammonia, formed freely in the soil when decaying vegetable matter is present, and although so exceedingly volatile when free, has but little

**Ammonia  
in the Soil.**

opportunity to escape into the air, as the soil water, and the various acids (humic, ulmic, etc.) resulting from the interaction of the carbon and oxygen in the soil, are quite apt to fix and hold it there for ready use of plants. Ammonia forms also quite freely in the excrements of animals, especially so in urine, and is just the substance that gives to these manures their great value and quick-acting character.

Nitrogen also combines with oxygen. These two elementary bodies, as already stated, exist in the atmosphere in a mere mixture; and that it needs considerable compulsion to make them unite chemically, is a fortunate thing for us, for the combination, nitric acid, is a most powerful, corrosive and destructive substance, and its free combination in the atmosphere might make things rather uncomfortable for living creatures. There is still a good deal



of mystery connected with the ways of nature in effecting a chemical combination between the two atmospheric constituents, as also in the formation of ammonia.

**Nitric Acid  
and Compounds.**

Even scientific men cannot wholly satisfy our thirst for more knowledge on this subject. The electric spark, passing through the atmosphere as lightning, is probably a most important factor in the creation of nitric acid, and perhaps of ammonia. Nitric acid is also produced in the soil from nitrogenous substances by means of a low form of organism. Scientists usually tell us of a "vegetable ferment," and then leave the matter to our imagination.

It must appear evident that nitric acid cannot be taken up by plants in this free and exceedingly corrosive form. The acid nature urges to a combination with an alkali whenever an opportunity is offering, and such is not lacking in nature. Nitric acid may find potash, and combining with it, form the harmless and well-known substance, saltpetre, or nitre; or it may combine with soda, forming nitrate of soda or Chili saltpetre (sometimes called cubic saltpetre from the form of its crystals), or it may combine with lime, forming nitrate of lime, or with magnesia, forming nitrate of magnesia, etc.

## SIXTH CHAPTER.

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### ACIDS, ALKALIES, AND SALTS.

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**I**N THE "ash" of plants, *i. e.*, in the small residue, left after any vegetable substance—wood, turf leaves, plant fibre, corn cobs, etc.—has been burned in the air, the dissecting (analyzing) chemist discovers a number of substances, those already named as inorganic (soil-derived) elements of plant growth, viz: calcium, chlorine, magnesium, phosphorous, potassium, silicon, soda and sulphur. Most of them appear in combination with oxygen, the elementary body which readily forms simple compounds with almost all other elements, whenever brought in contact with them.

**Simple  
Compounds.**

Some of these compounds are acids, others alkalies, others neutral substances. Thus we have the following compounds :

#### ACIDS :

Oxygen }  
Carbon } forming carbonic acid.

Oxygen }  
Nitrogen } forming nitric acid.

Oxygen }  
Phosphorus } forming phosphoric acid.

## ACIDS (CONTINUED).

Oxygen }  
Sulphur } forming sulphuric acid.

Oxygen }  
Silicon } forming silica (classed among the acids).

## ALKALIES :

Oxygen }  
Calcium } forming caustic lime, or calcium oxide.

Oxygen }  
Potassium } forming potash, or potassium oxide.

Oxygen }  
Sodium } forming soda.

## NEUTRAL SUBSTANCES.

Oxygen }  
Hydrogen } forming water.

Oxygen also combines readily with metals. The rust found on the unused plowshare or hoe is nothing more nor less than the result of a chemical combination of the iron with the oxygen of the atmosphere—iron oxide or iron rust. The green substance often seen on copper coins, etc., is copper oxide or copper rust, a simple compound of copper with oxygen.

Acids are also formed by the combination of hydrogen with a few elementary substances, but the only one worth mentioning in this treatise is:

Hydrogen }  
Chlorine } forming muriatic (or hydro-chloric) acid.

With nitrogen, on the other hand, hydrogen combines in the formation of an alkali that is most important to the soil tiller, namely:

Hydrogen }  
Nitrogen } forming the alkali—ammonia.

Another simple compound of importance to the farmer is the following :

Chlorine } forming chloride of sodium or common  
Sodium } salt.

Compounds between simple substances, as we have seen, are readily formed. These simple compounds, acids as well as alkalies, also have a strong desire to enter into more complicated chemical combinations; but, while neither of them can combine with a simple substance (or element), each acid seeks the union with an alkali, and each alkali the union with an acid. It is only the same old story. The male or positive principle in nature seeks the female or negative principle, and the female or negative principle cannot find its rest and satisfaction except in union with the opposite principle. We will also find that these simple compounds have their preferences—Miss Alkali accepting one Mr. Acid and refusing another when a choice is given. Some of the acids (called “strong acids,” sulphuric acid for instance) seem to be veritable “Don Juans,” stepping in between unions already formed, we might say, forcing a divorce by driving off the weaker acid and taking the bride. Carbonic acid is one of the “weak” ones, and often has to take a back seat. It happens that the weak party is content with taking up the alkali that the strong acid has cast aside for a more congenial union. The two parties then exchange partners—by a sort of double divorce and cross-marriage. A case of this kind is that of gypsum and ammonia.

It is not unusual to see married life modify or change prominent characteristics in both parties; to neutralize each other’s vices, harshnesses, or mischievous inclinations. A chemical union also, and

always, has a very decided influence of this kind. While acids and alkalies in their single blessedness may be ever so dangerous, poisonous or corrosive, they neutralize each other when combined, lose their acidity, or acridity, and become the entirely or comparatively harmless substances termed "salts."

I do not flatter myself that the table of acids and alkalies, or of the compounds (salts) which must enter in consideration in a treatise on agricultural chemistry, will afford as pleasant reading as many of the modern novels; but I am sure that the young farmer will find a thorough acquaintance with these substances, with which he has to deal in his farming operations, and some of which he finds mentioned in almost every issue of the agricultural paper he reads, far more profitable. The desire to know "what things are made of" is universal. The toys given to me during my childhood (and often those presented to the children of our neighbors) had to suffer from my inquisitiveness, and they were invariably subjected to a mechanical analysis before they had been in my hands many days. So it will always be a great satisfaction to any intelligent farmer to know the nature and composition of the various substances which he has to handle.

**Double Compounds  
or Salts.**

TABLE OF DOUBLE COMPOUNDS OR SALTS:

Oxygen	} forming carbonic acid	} forming carbon- ate of lime.
Carbon		
Oxygen	} forming caustic lime	
Calcium		
Oxygen	} forming carbonic acid	} forming carbon- ate of soda.
Carbon		
Oxygen	} forming soda	
Sodium		

Oxygen	} forming carbonic acid	} forming carbonate of potash or pearl ash.
Carbon		
Oxygen	} forming potash (potassium oxide)	
Potassium		

Oxygen	} forming nitric acid	} forming nitrate of lime.
Nitrogen		
Oxygen	} forming caustic lime (calcium oxide).	
Calcium		

Oxygen	} forming nitric acid	} forming nitrate of soda (Chili or cubic saltpetre).
Nitrogen		
Oxygen	} forming soda	
Sodium		

Oxygen	} forming nitric acid	} forming nitrate of potash (common saltpetre or nitre).
Nitrogen		
Oxygen	} forming potash	
Potassium		

Oxygen	} forming phosphoric acid	} forming phosphate of lime.
Phosphorus		
Oxygen	} forming caustic lime	
Calcium		

Oxygen	} forming sulphuric acid	} forming sulphate of lime (gypsum, land-plaster.)
Sulphur		
Oxygen	} forming caustic lime	
Calcium		

Oxygen	} forming sulphuric acid	} forming sulphate of soda (Glauber salts).
Sulphur		
Oxygen	} forming soda	
Sodium		

Oxygen	} forming sulphuric acid	} forming sulphate of magnesia (Epsom salts).
Sulphur		
Oxygen	} forming magnesia	
Magnesium		

Oxygen	} forming sulphuric acid	} forming sulphate of potash.
Sulphur		
Oxygen	} forming potash	
Potassium		

Oxygen	} forming sulphuric	} forming sulphate of iron (green copperas).
Sulphur		
Oxygen	} forming iron oxide	
Iron		

Oxygen	} forming sulphuric	} forming sulphate of copper (blue stone, blue copperas).
Sulphur		
Oxygen	} forming copper oxide	
Copper		

Oxygen	} forming carbonic	} forming carbonate of copper (mineral green).
Carbon		
Oxygen	} forming copper oxide	
Copper		

Hydrogen	} forming muriatic	} forming muriate (chloride) of potash.
Chlorine		
Oxygen	} forming potash	
Potassium		

Hydrogen	} forming ammonia	} forming sulphate of ammonia.
Nitrogen		
Oxygen	} forming sulphuric acid	
Sulphur		

Oxygen	} forming carbonic	} forming carbonate of ammonia.
Carbon		
Hydrogen	} forming ammonia	
Nitrogen		

## SEVENTH CHAPTER.

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### THE MINERAL PLANT CONSTITUENTS LIME, SALT, SULPHUR, SODA, MAGNESIA, AND SILICON.

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**L**IME is a substance well-known to every reader. When freshly burnt, as quick lime or caustic lime, it is a chemical combination of the metal calcium with the gas oxygen having a great affinity or passion for water and for carbonic acid. If exposed to the air, it absorbs moisture, and after awhile falls in the fine powder known as "air-slacked lime." Afterwards it also absorbs carbonic acid from its surroundings. We can often put this passion of burnt lime for the two substances to good use in various ways. We know that every **Lime.** three pounds of it absorbs one pound of water, and that it takes it wherever it finds it. Undue or excessive dampness in cellars, tomato forcing houses, etc., may be easily removed, or greatly reduced, by placing boxes containing burnt lime in such buildings or rooms; and cellars, mines, wells, etc., can be cleared of the poisonous carbonic acid gas, if any such exists in them, by a few handfuls of freshly-slacked lime.

Lime combined with carbonic acid exists in great



profusion in nature. It forms whole mountains, and many soils are largely composed of it. The shell-marls are almost pure "carbonate of lime" (chalk), as this combination of lime is named, and most soils are abundantly supplied with it. Lime is indispensable to the healthy growth of cultivated crops, and where it is deficient, as in many peaty soils, such crops must suffer unless lime is applied in some form. It should also be remembered that the natural formation of nitric acid in the soil (by the conversion of nitrogenous matter, mysteriously but conveniently called "nitrification"), is dependent on the presence of lime, soda, or some other base. Suppose we have a peaty soil unfit to produce good crops on account of its acidity and deficiency of lime. If we then apply fresh-burnt (caustic or quick) lime, its very first action will be to combine with and neutralize the free acids, and thus sweeten the soil. Some of the new compounds are often immediately utilized for plant food. The lime also breaks up compounds in which potash, ammonia and soda are held in an insoluble condition, and makes these substances available for plant food. It further hastens the decomposition of organic matter in the soil and otherwise aids in furnishing plants with the available compounds they desire.

Lime is usually applied in the form of air-slacked lime, marl or in other forms of carbonate of lime. Peaty soils are often underlaid with a layer of marl (generally almost pure carbonate of lime, which, owing to the natural tendency of lime to sink in the soil, has, in the course of centuries, been deposited upon an impervious clay subsoil); hence such form of lime is generally readily accessible for use on these kinds of soil. Here it may directly afford

food to plants. It removes the sourness of sour soils, yielding carbonic acid, and promotes the slow growth or formation, from nitrogen compounds, of nitric acid, with which it combines, forming nitrate of lime, a compound having about the same value as plant food and the quick effect of nitrate of soda. On heavy clay soils it also exerts a beneficial mechanical action, rendering them more open and porous, helping to admit air, and to liberate locked-up plant foods.

It will be seen from all this that the application of lime, in one form or another, is decidedly beneficial to a certain extent, and especially so far as immediate results are concerned. When overdone or long continued, however, lime applications without other fertilizer tend to ultimate soil exhaustion by hastening the removal of the scarcer and more valuable plant foods (potash, phosphoric acid and nitrogen), either when consumed by and taken off with the crops, or when allowed to escape into the drains, as all nitrates are inclined to do, unless caught and held by growing plants. It is good logic what our forefathers expressed in the rhyme :

Lime without manure

Makes the father rich and the children poor.

The refuse lime of the gas works is frequently spoken of both as a fertilizer or rather stimulant, and as a repeller or destroyer of injurious insects. Prof. Caldwell, of Cornell University, gave me his opinion of its value as follows:

“Gas lime is composed chiefly of carbonate of lime and varying quantities of sulphate of lime (or ordinary land plaster), sulphite of lime, sulphide of lime, and more or less unchanged lime. The sulphite and sulphide are

**Gas Lime.**

harmful to vegetation, especially the latter; but on exposure of the gas lime for a considerable time to the air they become changed to the useful sulphate. The carbonate is of little value, and only the sulphate and the unchanged lime can be counted on as of any use.

“I do not consider the material as of much value for fertilizing purposes; for after due exposure to the air, to render the sulphide and the sulphite harmless, the unchanged lime will also, in this time, be converted to carbonate, so that only the sulphate is left to be useful; and if I were going to use land plaster, I would prefer to buy it outright and know what I have.

“As an insecticide its use would be dangerous, because of its effect on the plant itself, unless it has been well aired, and as for its usefulness in this respect after having been thus aired, it would be same as a mixture of plaster and chalk.”

Besides these compounds (carbonate and nitrate), lime enters into still other important combinations, especially with phosphoric acid, forming phosphate of lime; and with sulphuric acid, forming sulphate of lime (gypsum). More will be said about these further on.

The aristocratic name given to the simple compound of the element chlorine, a poisonous gas, with the element sodium is “chloride of sodium.”

**Common  
Salt.**

Ordinarily it is called salt. Both of its component parts can serve as plant food.

The oxide of the metal sodium is soda. Some plants, like beets, turnips, etc., contain considerable chlorine and still more of soda. For this reason the application of this chloride of sodium (common salt) is found to be quite beneficial for such

crops on some soils. As a general thing, however, soda, chlorine, as also magnesia—which is an oxide of the metal magnesium—are present in sufficient quantities in the soil; and we have no reason whatever to worry about means how to get them. This is also generally the case with silica (oxide of silicon, silic acid), as it constitutes a large percentage of our common soils in the shape of finely divided quartz, flint, rock crystal.

Chlorine, as stated, acts favorably upon some plants under certain conditions. From this it should not be inferred that the substance is a safe plant food. It is death to most plants if applied freely. Salt is recommended for killing weeds. The executioner, in this case, is the chlorine in the salt, and we have to handle this substance somewhat carefully. The German potash salts (muriate, kainit) contain considerable chlorine, either as impure salt or as chloride of potash, and large applications on some soils and for some crops may result in injury and disappointment.

Sulphur enters plant structure in comparatively small quantities only, and as it is most abundant in nature, and cheaply obtained, hardly deserves serious consideration in its character as plant food. In its combinations, however, it looms up as a most important agent of rendering other plant foods available, and of preventing their waste and loss. Combined with oxygen, it appears as the well-known, cheap, powerfully corrosive substance, "sulphuric acid," and thus it usually appears in plant structure.

In gypsum, or sulphate of lime, we have a combination of sulphuric acid with lime and water; in plaster Paris the same compound without water.

Being soluble in 400 times its bulk of water, gypsum supplies to plants both sulphuric acid and lime, perhaps directly. Its great value lies in its action upon ammonia, which in its usual form of carbonate of ammonia is exceedingly volatile. For this it proves a most excellent and effective trap—a trap which a good farmer should not fail to keep well set in his stables and on manure heaps. The sulphuric acid exerts its superior power by tearing the ammonia from its combination with carbonic acid and taking it to its own heart, forming the compound “sulphate of ammonia,” (which is held in the soil or manure until taken up by the plants, or converted into nitrates), and leaving the carbonic acid and

**Sulphuric  
Acid.**

lime to get along as best they may in the new union of carbonate of lime.

Here again we have sulphuric acid in the role of caterer or provider of plant food to needy crops.

In a practical treatise we have little occasion to speak of the compounds of sulphuric acid with soda and magnesia, sulphate of soda and sulphate of magnesia, as we do not need to apply them as plant foods. Sulphate of potash, the combination of sulphuric acid and potash, will be spoken of later on.

The compound sulphate of iron (green copperas, iron vitriol) is reported to have been applied to the soil with apparently beneficial effect, adding luxuriance to the foliage, and darkening the green color. But this cannot possibly be due to its character as a plant food, and may find its explanation in the action of the acid, either upon plant foods already in the soil, making them available when locked up, or upon the spores of fungous diseases of plants, depriving them of their power of germination.

The compound sulphate of copper (blue vitriol, bluestone, copper vitriol) is valuable as a spore killer and preventive of fungous diseases of plants and now largely used for the prevention of grape mildew and rot, potato rot, tomato blight and rot, melon blight, and many other fungous enemies to our crops. So also is carbonate of copper.

Another, and most important use made of sulphuric acid, is in the treatment of bones and phosphatic rocks by which they are transformed into so-called superphosphates, and rendered soluble and consequently immediately available for plant food.

The compounds of silica constitute a large proportion of the earth's surface. The tiny, glossy pieces of "sand" or quartz which abound everywhere,

**Silicates.** are almost pure silicious acid (silica); and the rocks, sandstones, the soil—all contain it in abundance. So we have the silicates of alumina, potash, soda, etc. The element silicon, although not exactly indispensable to plant growth, enters quite largely into plant structure, especially near the outside, and is the substance which gives the glossy, hard surface to the stems of cereals and grasses, thus adding stiffness to the stalks and making them self-supporting. It is also true that a vast store of unavailable potash is held in some of these silica compounds. This potash is gradually rendered soluble and fitted for the use of plants by the slow process of disintegration and decomposition, through the action of carbonic acid, etc., as the years roll by. I mention this merely to show that we can expect at least some assistance from every soil in furnishing us this needed substance of plant food.

## EIGHTH CHAPTER.

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### THE MINERAL PLANT CONSTITUENTS PHOSPHORUS AND POTASSIUM.

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WE NOW come to a consideration of the substances of plant food, which with available nitrogen are of more than ordinary interest to the farmer. All other substances needed for plant growth are so generally and abundantly provided in average soils, that they need not give us any serious concern. The supply of available phosphorus and potassium, like that of nitrogen, however, becomes exhausted by continued cropping, and we find ourselves confronted by the necessity of supplying the deficiency, or of ceasing to produce crops.

The element phosphorus has a strong liking for oxygen, and it unites with it on the slightest provocation. A "mere scratch," or the least friction, is sufficient to make it flare up in a sudden outburst of fire, resulting in a violent union of the two elements, and thus forming phosphoric acid. This is an occurrence that comes under our daily observation.

**Phosphoric  
Acid.**

The colored mixture at the end of a common

match contains a small quantity of phosphorus. A slight scratch, or the sole of your boot placed upon it on the barn floor, or the mere nibbling of a mouse or rat, is sufficient to provoke the atom of phosphorus to unite with the oxygen of the air; thus, in one case, giving you the means to light your pipe or the kindling in the stove, or, in the other case, setting barn or house on fire. The product of the union of the two elements is a cloud of dense, whitish fumes, and consists of the often-mentioned, all-important plant food, phosphoric acid.

We need not concern ourselves about the characteristic features of this simple compound, its corrosiveness, sour taste, its solubility in water, etc., for we find it in plant and animal structure only in combinations with lime, soda, potash and other bases, and in these forms fortunately for us, it is universally diffused, and very plentiful in nature.

Phosphate of lime is by far the most important and the most common of these combinations; and we find it in inexhaustible natural deposits as apatite, or mineral phosphate of lime; in the remains of

**Phosphates.** animals; in phosphatic guanos (leached dung of sea fowls), etc.

South Carolina and Florida furnish vast quantities of phosphate rock. More than one half of the dry substance of animal and human bones consists of phosphate of lime, and nearly one half of the latter consists of phosphoric acid. Flesh and other animal tissues have also some phosphate of lime, and each one hundred pounds of dried bones contain about twenty-eight pounds of phosphoric acid.

In animal manures, especially in the liquid voidings of living creatures, we find another and more concentrated form of phosphoric acid—a double



phosphate (bi-phosphate) of lime, containing more than seventy per cent of the acid, and a very valuable form of plant food. There are other compounds of phosphoric acid, as for instance, phosphate of magnesia, which also enters into plant and animal tissue; phosphate of soda, of potash, etc., but phosphate of lime is really the only compound of this acid of real importance to us as a source of plant food, and in bones, guano, phosphate rock, and Thomas' or basic slag (phosphate meal, odorless phosphate) we have the only stores worth mentioning from which we can draw our supply of phosphoric acid.

The compound "phosphate of lime," wherever found as a natural product, is firmly fixed, and does not readily yield up its phosphoric acid to the use of plants. The lime holds the acid in firm embrace. In sulphuric acid, however, we have a means of breaking the combination. This powerful acid, when brought in contact with phosphate of lime, forces some of the lime to part with its phosphoric acid, and enters with this lime into a new union—sulphate of lime or gypsum. The phosphoric acid thus freed or driven off, attaches itself lightly to the remaining lime, forming with it a double or bi-phosphate. By the addition of more sulphuric acid this process may be repeated until we have a treble phosphate, generally called a superphosphate, which is a little lime and a great deal of phosphoric acid. The excess of the latter, however, is always ready to leave the companionship of the lime in the regular phosphate of lime combination on short notice, either to sacrifice itself for use by plants, or to enter new and more congenial combinations with free lime, soda, etc., in the soil. When the latter

process takes place, we have the so-called "reverted phosphoric acid."

Neither the element potassium, nor its compound with oxygen (potassium oxide, ordinarily called "potash") is ever met with in nature in a free form.

**Potash.** The form in which everybody is familiar with it, is "carbonate of potash," a compound of potassium oxide (or potash) with carbonic acid. This compound is readily soluble in water. It appears in fresh wood ashes, in corn cob ashes, in cotton seed hull ashes, etc.; and no better form is known in which potash could be applied to the soil, or utilized as plant food.

In chloride of potassium we have a simple compound of the metal potassium with chlorine. This is found in sea water, and in the potash salts mined at the salt mines near Stassfurt in Prussia, Germany, and known as muriate of potash. Sulphate of potash, obtained from the same source, is a compound of potash with sulphuric acid, and kainit a sulphate of lower grade.

One of the most valuable, but also expensive, forms of potash, is the compound of potash with nitric acid, known as nitrate of potash or saltpetre. This furnishes two elements of plant food at the same time, potash and nitrogen (the latter in the available nitrate form), and is found in large beds in South America, and also produced naturally in any soil containing decaying vegetable matter and potash, or artificially in so-called nitre beds. Potash also exists in combination with several other acids, as with oxalic acid in rhubarb, with citric acid in lemons, oranges, etc., and with tartaric acid in grapes.

## NINTH CHAPTER.

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### CHEMICAL SYMBOLS, FORMULAS, AND ATOMIC WEIGHTS.

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The Experiment Station chemists, and other writers on matters pertaining to fertilizers, frequently make use, in bulletins and agricultural journals, of a system of lettering and figuring which somewhat resembles the mysterious signs and characters found in physicians' prescriptions. The aim I have in view in writing this chapter, is to give to those who wish to fathom all these mysteries, a clue for the understanding of the true meaning of such sign-writing. While an intimate knowledge of it is not indispensable for the full understanding of the problems treated in the second and third parts of this volume, yet on the other hand, the young man who aspires to a front rank among progressive farmers, cannot afford to remain in entire ignorance of all these things.

The explanation of the mystery is as follows: All chemical elements are represented by symbols which are the first letters of their respective names. Only

where different elements have the same initial letter a small letter is added. Thus

O	stands for oxygen.
H	“ “ hydrogen.
C	“ “ carbon.
N	“ “ nitrogen.
S	“ “ sulphur.
P	“ “ phosphorus.
K	“ “ potassium (Latin: <i>kalium</i> ).
Cl	“ “ chlorine.
Na	“ “ sodium (Latin: <i>natrium</i> ).
As	“ “ arsenic.
Cu	“ “ copper (Latin: <i>cuprum</i> ).
Mg	“ “ magnesium.
Fe	“ “ iron (Latin: <i>ferrum</i> ).
Si	“ “ silicon.

The meaning of the letter or character, however, does not end with this. It does not merely represent the substance or element, but also indicates a certain quantity of it—and this quantity is the atom—the ultimate unit of the chemist, and the smallest imaginary particle of the element in question. Such an atom is indivisible, unchangeable and indestructible.

The atom is the smallest quantity of an elementary substance that can enter into a chemical combination with other atoms. A group of such chemically combined atoms forms a molecule, which is the smallest imaginary particle of a compound substance. Such molecule is subject to many changes. Under the term “chemical analysis” we understand the process of tearing a molecule asunder for the purpose of discovering its component atoms.

Now the atoms of all these elements, when entering combinations, have a fixed relative weight. The hydrogen atom (H) being the lightest, its

weight is taken as 1. On that basis the atomic weights (or numbers representing the comparative weights of atoms—the atomic numbers) are as follows, viz.:

Hydrogen	(H)	-	-	-	-	-	-	1
Carbon	(C)	-	-	-	-	-	-	12
Nitrogen	(N)	-	-	-	-	-	-	14
Oxygen	(O)	-	-	-	-	-	-	16
Sodium	(Na)	-	-	-	-	-	-	23
Magnesium	(Mg)	-	-	-	-	-	-	24
Silicon	(Si)	-	-	-	-	-	-	28
Phosphorus	(P)	-	-	-	-	-	-	31
Sulphur	(S)	-	-	-	-	-	-	32
Chlorine	(Cl)	-	-	-	-	-	-	35.5
Potassium	(K)	-	-	-	-	-	-	39.1
Calcium	(Ca)	-	-	-	-	-	-	40
Iron	(Fe)	-	-	-	-	-	-	56
Copper	(Cu)	-	-	-	-	-	-	63.5
Arsenic	(As)	-	-	-	-	-	-	75

A group of atoms (or molecule) forming a chemical compound, is represented by writing together the symbols or characters of the atoms. The molecule of hydrochloric (or muriatic) acid, for instance, consists of one atom each of hydrogen and chlorine, consequently it is represented in this way: H Cl. Few compounds, however, are formed in this simple way. Sometimes two, sometimes three or more atoms of the same element are required in the formation of a chemical compound with atoms of other elements. The molecule of water consists of two atoms of hydrogen, and one of oxygen. Its symbol is: H<sub>2</sub>O. Small arabic figures, following after the letter which represents an elementary atom, always indicate the number of such atoms. O<sub>2</sub> means two atoms of oxygen; P<sub>4</sub> four atoms of phosphorus, etc. To represent several groups of atoms (molecules) a large figure is placed before the symbol of the compound. H<sub>2</sub> O represents a single molecule of water;

$2 \text{H}_2\text{O}$  represents two such molecules, and is equivalent to  $4\text{H}+2\text{O}$ .

The following is a list of formulas of those compounds which chiefly interest the soil worker, viz.:

$\text{H Cl}$	stands for muriatic (hydrochloric) acid.
$\text{Na Cl}$	“ “ common salt.
$\text{Na}_2 \text{CO}_3$	“ “ carbonate of soda.
$\text{Na HO}$	“ “ hydrate of soda or caustic soda.
$\text{Na}_2 \text{SO}_4 + 10\text{H}_2 \text{O}$	stands for sulphate of soda (Glauber salts).
$\text{Na NO}_3$	stands for nitrate of soda or Chili saltpetre.
$\text{KHO}$	“ “ hydrate of potassium (caustic potash).
$\text{K}_2 \text{CO}_3$	“ “ carbonate of potash.
$\text{K NO}_3$	“ “ nitre or saltpetre (nitrate of potash).
$\text{K}_2 \text{SO}_4$	“ “ sulphate of potash.
$\text{K}_2 \text{O}$	“ “ potassium oxide.
$\text{H}_3 \text{N}$	“ “ ammonia.
$\text{NO}_2$	“ “ nitrous acid
$\text{NO}_3$	“ “ nitric acid.
$\text{NH}_4 \text{Cl}$	“ “ sal-ammoniac.
$\text{NH}_5 \text{O}$	“ “ aqua ammonia.
$\text{Ca}_3 \text{P}_2 \text{O}_8$	“ “ phosphate of lime.
$\text{As}_2 \text{O}_3$	“ “ arsenious acid.
$\text{P}_2 \text{O}_5$	“ “ phosphoric oxide (acid).
$\text{H}_2 \text{O}$	“ “ water.
$\text{H}_2 \text{S}$	“ “ sulphuretted hydrogen.
$\text{SO}_2$	“ “ sulphurous oxide.
$\text{SO}_3$	“ “ sulphuric oxide.
$\text{H}_2 \text{SO}_3$	“ “ sulphurous acid.
$\text{H}_2 \text{SO}_4$	“ “ sulphuric acid.
$\text{Cu SO}_4 + 5\text{H}_2 \text{O}$	stands for sulphate of copper (blue vitriol).
$\text{Ca O}$	stands for lime (caustic or burnt lime, quick lime).
$\text{Ca H}_2 \text{O}_2$	“ “ slacked lime.
$\text{Ca SO}_4$	“ “ sulphate of lime (plaster of Paris).
$\text{Ca SO}_4 + 2\text{H}_2 \text{O}$	stands for gypsum (land plaster).
$\text{Ca CO}_3$	stands for carbonate of lime.
$\text{Mg O}$	“ “ magnesia (magnesium oxide).
$\text{Mg SO}_4 + 7\text{H}_2 \text{O}$	stands for Epsom salts (sulphate of magnesia).
$\text{Fe SO}_4 + 7\text{H}_2 \text{O}$	stands for sulphate of iron (copperas).
$\text{Si O}_2$	stands for silica.
$\text{CO}_2$	“ “ carbonic acid.
$\text{CH}_4$	“ “ marsh gas.

The reader may ask me: What good to us is there

in these formulas or symbols? In the first place they tell us at a glance of what elements any of these substances are composed. But they do still more. They, secondly, enable us to figure out the exact proportion of any element in the compound.

For instance, we desire to discover how much nitrogen there is in a given quantity of ammonia ( $H_3N$ ). The compound consists of three atoms of hydrogen and one of nitrogen. The atomic weight of hydrogen was given as 1; the atomic weight of nitrogen as 14. Thus we have

3	H	@	1	=	3
1	N	@	14	=	14
					<hr style="width: 10%; margin: 0 auto;"/>
Total,	-	-	-	-	17

The compound has an aggregate of 17 weight units, of which nitrogen has 14. In other words: in every 17 lbs. of ammonia we have 14 lbs. of nitrogen and 3 lbs. of hydrogen.

Another instance. We have a chemically pure sample of nitrate of soda ( $NaNO_3$ ), and wish to figure out the percentage of nitrogen—which is the element of value in the compound.

The atomic weights are as follows:

Na (one atom of sodium @ 23)	-	-	-	-	23
N (one atom of nitrogen @ 14)	-	-	-	-	14
$O_3$ (three atoms of oxygen @ 16)	-	-	-	-	48
					<hr style="width: 10%; margin: 0 auto;"/>
Total,	-	-	-	-	85

Thus in every 85 weights of the compound we have 14 weights of nitrogen; in every 1 lb. of the compound  $\frac{14}{85}$  lb. nitrogen; in every 100 lbs. of the former  $1\frac{40}{85}$  lbs. or 16.47 per cent. of nitrogen.

Still another example. We wish to find out what

percentage of phosphoric acid ( $P_2O_5$ ) is contained in phosphate of lime ( $Ca_3P_2O_8$ )?

Phosphate of lime consists of

$Ca_3$ (three atoms of calcium @ 40 weight units)	-	120
$P_2$ (two atoms of phosphorus @ 31 weight units)	-	62
$O_8$ (eight atoms of oxygen @ 16 weight units)	-	128
Total,	- . . . . .	<u>310</u>

Phosphoric acid consists of

$P_2$ (two atoms of phosphorus @ 31 weight units)	-	62
$O_5$ (five atoms of oxygen @ 16 weight units)	-	80
Total,	- . . . . .	<u>142</u>

Thus we find in every 310 weights of phosphate of lime 142 weights of phosphoric acid, which is equal to 45.80 per cent.

END OF FIRST PART.

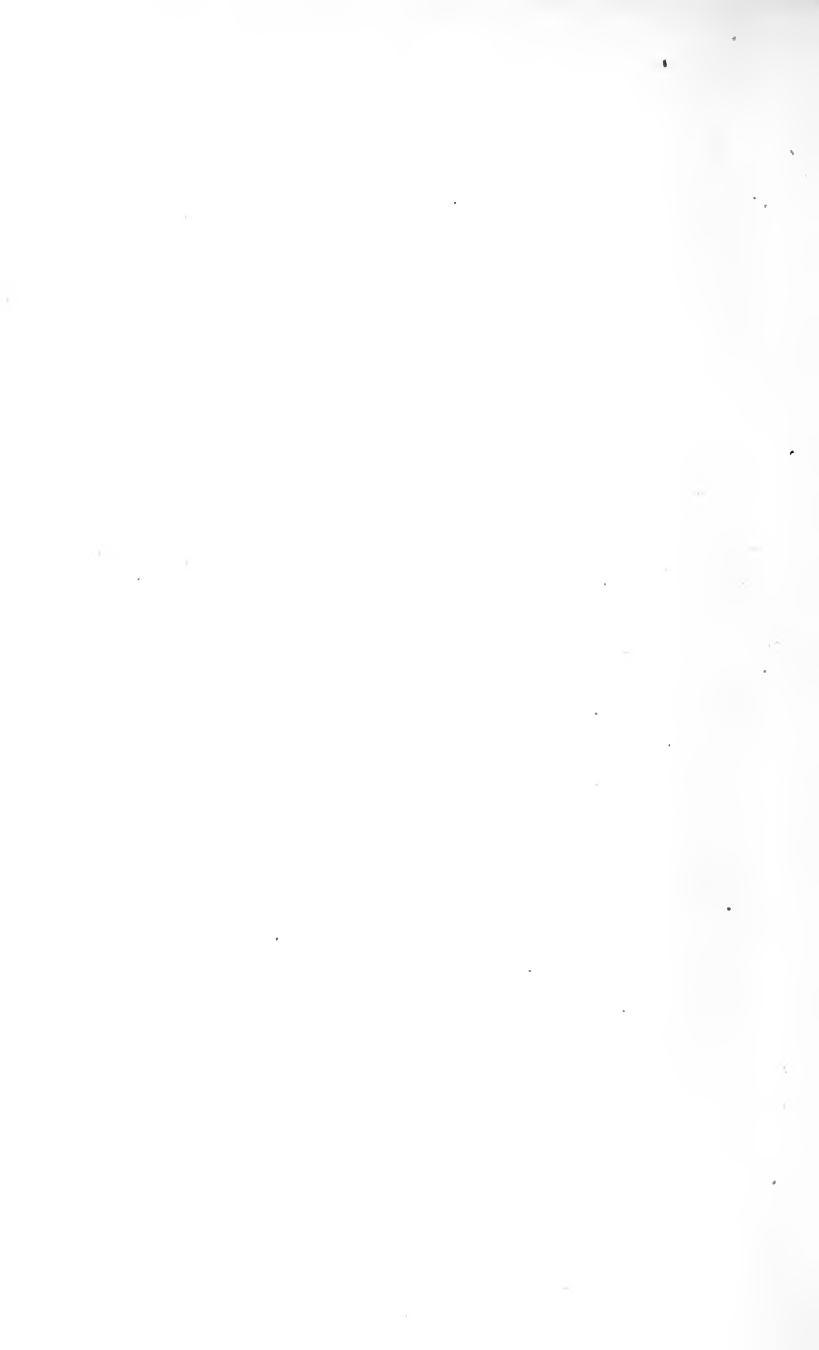


PART II.

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THE AVAILABLE SOURCES  
OF  
SUPPLY.

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## TENTH CHAPTER.

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### WHAT OUR SOILS ARE MADE OF.

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**T**HE SOIL, which we work, is in itself the most important of all of our available sources of plant food. It must be of interest to examine its structure and general constitution, even before entering the question of the food elements which are contained in it.

All soils have more or less organic matter derived from the decay of animal, and still more of vegetable, substances. The proportion of such organic matter in naturally productive soils varies between a mere fraction of one, and seventy per cent of its entire weight. In our best soils the organic matter ranges from five to twelve per cent, seldom more. Only in mucky and peaty soils does the amount of organic matter ever exceed that of the inorganic or earthy matter.

The inorganic or earthy part of the soil consists principally of silica or silicious sand, alumina (as

clay or slate), and lime (as carbonate or chalk). Clay, or pure clay, as seen from the farmer's standpoint, is a compound of about forty per cent of alumina—a metallic earth, the oxide of the metal aluminum—and about sixty per cent of silica or sand. The great tenacity of the compound is due to the alumina. The sandy matter contained in it, being in chemical union with the other, cannot be separated from it by mere mechanical means, as washing or boiling.

**Classification  
of Soils.**

Soils are usually classified as follows :

1. Pure clay, or pipe clay—not often met with to any great extent.

2. Strong clay, or tile clay, consisting of pure clay and five to fifteen per cent of silicious sand, which latter is easily separated from the clay by washing.

3. Clay loam, consisting of pure clay with fifteen to thirty per cent of sand, separable by washing.

4. Loam or ordinary loam, containing pure clay with thirty to sixty per cent of sand.

5. Sandy loam, containing sixty to ninety per cent of sand.

6. Sandy soil, containing upwards of ninety per cent of sand.

7. Calcareous soils, containing five to twenty, or more, per cent of carbonate of lime. According to the proportion of clay and sand contained in them, we call them calcareous clays, calcareous loams, or calcareous sands.

8. Vegetable moulds, such as rich old garden soils, containing a very large per cent of decayed animal and vegetable substances, as the result of often-repeated, heavy applications of bulky manures; or peaty and mucky soils, containing thirty to seventy per cent of organic matter.

The larger the proportion of clay in any soil, the more tenacious, the stiffer and closer, but also the lighter in weight it is. One cubic foot of strong, clay loam, for instance, weighs eighty to ninety pounds, while one cubic foot of sandy soil weighs 110 pounds. The same bulk of peat or muck, however, weighs only from thirty to fifty pounds.

Even the most superficial examination will show to the intelligent farmer whether a given soil belongs to the class of sandy, clayey, or mucky soils. Still, the finer distinctions may become a matter of doubt or dispute. The difference between sandy loam, ordinary loam, and clay loam, are not always readily recognized by outward appearances. It is not, however, a difficult task, even for the novice in such matters, to determine, by simple tests, the percentage of the principal substances contained in any given soil; at least, near enough for all practical purposes, and thus be enabled to correctly tell the class to which that particular soil belongs.

I will tell how I made a soil analysis of this kind a short time ago. The soil to be examined was what I supposed to be a clay loam, well provided with humus (organic matter). I happened to have a pair of sensitive laboratory scales on hand, but my supply of weights being limited to an aggregate of about 250 grains, I was compelled to take two grains as weight unit, although for the sake of greater accuracy, I would have preferred a unit of ten grains.

**A Simple  
Soil Test.**

At first I weighed off 200 grains of the soil, freshly taken up, moist but crumbly, and spread this thinly on a sheet of paper, placing this upon the grate of a hot oven for an hour or more. When thoroughly dried, it was then again weighed, and



gave 159 grains, the loss (forty-one grains, or twenty and one-half per cent) representing the amount of moisture in the soil when first taken up.

In order to find the percentage of sand in the dry matter, another lot of fresh soil had in the meantime been dried in the same way as the first 200 grains. I now weighed off 200 grains of the dry soil, and thoroughly dissolved it in boiling water. More water was then added to make the mixture quite thin, and after a thorough stirring, the sand was given a chance to settle to the bottom of the vessel, when the muddy liquid on top was carefully poured off. Next, I added more water, stirring as before, and pouring off the liquid from the sand when settled. This process was repeated several times, until I had reason to believe that the sand in the vessel was pretty well freed from the clay and other matter. The residue of sand was then dried, put upon a stove-shovel, and this exposed to sufficient (red) heat to free it from any organic matter possibly left in it. The weight of clear sand was then ascertained, and found to be forty grains, or twenty per cent.

In order to get at the percentage of organic matter, another 200 grains of thoroughly dried soil was weighed off, placed upon a stove-shovel, and this upon a bed of live coals in the stove, until the whole had become red hot, and the humus, or organic matter, was all consumed by combustion. The residue was then allowed to cool, and its weight ascertained to be 182 grains. The loss, eighteen grains, or nine per cent, represents the organic matter.

The analysis might here be considered at an end, and sufficient for all practical purposes. But I also desired to ascertain the percentage of lime, and for

that purpose put the 182 grains of soil, as freed from water and organic matter, into a pint of water, adding one half pint of muriatic acid, and stirring the whole together. This was left standing for several hours, until bubbles had ceased to rise from the bottom. The liquid part was then carefully poured off, the residue dried in a hot oven, and the weight again ascertained. This was found to be 176 grains, indicating a loss of six grains, which represents the amount of lime, and equals three per cent. Thus we have

Moisture in the fresh soil,	-	-	-	20½ per cent.
Sand in the dry soil,	-	-	-	20 " "
Organic matter in dry soil,	-	-	-	9 " "
Lime in dry soil,	-	-	-	3 " "

What lessons are to be learned from this? First, that this particular soil is a rather strong clay loam, which might be improved in porosity, warmth and general manageability by addition of sandy matter. Second, that the soil is very liberally supplied with organic matter, and presumably in a fine state of fertility. Third, that lime is not wanting. Fourth, that we might expect fair returns from the judicious use of concentrated fertilizers on this soil.

The different classes of soils behave differently in various respects, especially in their relation to change of temperature, and in their capacities of absorbing and holding moisture. Sand both heats and cools off quicker than loam; this quicker than clay; and this quicker than peat or muck. As a rule, dark-colored soils absorb heat quicker, and are consequently warmer in the day, but also cooler in the night, than light-colored ones.

Of all soils, pure sand has the least capacity for absorbing moisture from the air, as well as for hold-

ing water once taken up. This power increases in any soil with the proportion of clay, and still more with that of organic matter in it. Peat, and muck absorb and hold great quantities of moisture, and this sponge-like character, while too prominent to be entirely desirable in such soils themselves, renders them valuable as an addition to sandy soils for the purpose of increasing their absorptive and retentive capacities.

Perhaps the most important quality of clay is its power of absorbing plant foods, such as phosphoric acid, potash, ammonia, lime, etc., and holding them for the use of plants. Hence soils of a somewhat clayey character can usually be kept in fertile condition much more easily than soils that are composed mostly of sand.



## ELEVENTH CHAPTER.

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### THE SOIL AS CHEAPEST SOURCE OF PLANT FOOD.

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**B**ESIDES the chief constituents named in preceding chapter, the average soil also contains smaller amounts of a number of other substances, especially iron in the form of oxide of iron, magnesia, soda, sulphuric acid, chlorine, and the great indispensables—potash and phosphoric acid. The percentages of any of them may be large, and of some only small fractions, or even mere traces, yet the aggregate amounts contained in an acre of good arable soil, one foot in depth, are considerable. The weight of these 43,560 cubic feet of soil, when dry, will be in the neighborhood of 4,000,000 pounds, and in these there may be 30,000 to 40,000 pounds of nitrogen, 25,000 pounds of potash, 15,000 pounds of phosphoric acid, not to mention the substances of minor importance to us. These are enormous quantities. The virgin soil in fertile sections is often chockfull of plant foods, and while

the most of it exists in fixed combinations, and is not immediately available, yet there is enough of it thus ready for the use of plants, or becomes so in the course of time, to produce the most luxuriant plant growth year after year for a long period, perhaps for generations. At first the crops are such as not to be equalled on soils having been long in cultivation even with heaviest manuring. Then gradually the yields become smaller, as the available plant foods are removed from the soil, year after year; and unless the stock is replenished, the soil must after a while become exhausted, "worn-out," and unproductive. The reduced stock of the plant foods is not rendered available any more as fast as the plants need it for the production of paying crops. In place of the original soil, capable of producing forty or fifty bushels of wheat to the acre, and other crops in proportion, and all this without the aid of costly applications of manures, we now have a piece of land, that unaided, will give us a yield of eight or ten bushels of wheat, and not more than double that amount at best, provided we supplement its natural stores with an additional five or six dollars' worth of plant food.

I have drawn this comparison for the purpose of calling attention to the great value of the stores of plant food in fertile soil. If we buy an acre of rich land, we buy with it at least 20,000 pounds of nitrogen, 12,000 pounds of potash and 6,000 pounds of phosphoric acid, which if we had to purchase it in fertilizers at lowest wholesale rates, would cost us no less than \$2,000. Such soil, wherever found, is in itself a rich mine, and worth money. The purchaser can afford to pay \$100 or \$200 an acre for it much better than ten or twenty dollars an acre for soil

deprived of most of its original store of plant food. If any element of plant nutriment can be purchased at a cheaper rate than in rich soil, at ordinary prices, I have yet to learn of it.

Suppose this rich land is bought at \$200 an acre. The money is safely invested, and well secured. Heavy interest is paid from the very beginning. Success begins with the first crop. It will take little effort and comparatively slight expense to keep good soil permanently in a fine state of fertility, and the owner on the road to prosperity.

The tiller of the poor soil on the other hand starts in with an annual loss, and only good management, and liberal use of plant foods enables him to reduce this loss from year to year, and continuing thus, turn it to profit after many years' efforts. If he be not a good manager, the loss will be permanent, and the land not any better at the end than at the beginning of his period of management.

Some of the old market gardens, near the cities, have been turned into manure themselves by the abundant dressings of composts they have been given year after year. The plant foods contained in one acre of such soil, if they were to be purchased in the form of commercial manures, would be worth more than \$3,000. Of course, these old market gardens can not be bought for a song; but their value is not alone in the plant foods they contain, but also in their proximity to the market. A good market alone may add \$2,000 or more to the value of an acre of land in the near vicinity.

All this, however, is a little foreign to my subject. My aim was to call attention to the great advantages found in fertile soil, and to warn against the purchase of worn-out land. The latter, even if worth

its price, is not often worth the effort and labor and manure necessary to grow a crop on it. To make it productive and profitable is up-hill business. The "cheap land" bait leads into a dangerous, and usually, fatal trap. Don't throw your life away on poor soil! Fight shy of the worn-out farms! One acre of soil possessing the great reserve stores of the essential plant foods, is worth ten, yea twenty acres of soil that in its natural condition will yield only six or eight bushels of wheat per acre, or other crops in proportion. Be sure to begin right. You may begin small. A small farm is safer to begin with than a large one; but let the soil be fertile. You will seldom be able to purchase plant food—the raw materials you need for the production of paying crops—in a cheaper form than when already mixed with the soil.

## TWELFTH CHAPTER.

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### THE ESSENTIAL PLANT FOODS AND THEIR TRADE VALUES.

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**I**N OUR lists of elementary bodies and simple compounds we find only three about which we have occasion to worry to any considerable extent. These are nitrogen, potash and phosphoric acid. All the rest are generally provided in greater abundance in any soil than needed for the fullest development of the plants. Any application of manure, or fertilizers of any kind, is made for no other purpose than to provide our growing crops with one, or two, or all three of these substances, and even in case of application of lime, plaster, salt, etc., which in themselves contain no plant foods, our object is usually in the direction of freeing one or the other of these nutrients from the grasp of other substances with which they have formed insoluble compounds in the soil.

Speaking of nitrogen, it may be well to call particular attention to its relation with ammonia. Writers, dealers in fertilizers, and growers, are in

the habit of speaking of ammonia as one of the chief plant foods. We have seen that ammonia is the compound hydrogen-nitrogen, each seventeen pounds of it containing fourteen pounds of the nitrogen, which we want, and three pounds of hydrogen, which we care little about. As an element of plant food, therefore, it were much better if we would confine ourselves to the proper term, nitrogen, rather than make a confusing mess of it by wrongfully substituting for it the name of the compound ammonia, as is so often done in common farm parlance. In older works, and occasionally in the columns of our farm papers, we come across the term "potential ammonia." This means the amount of ammonia which the nitrogen, in whatever form it appears, might produce by fermentation. I think we should dispense with the term altogether. Fertilizer manufacturers, in giving the legally demanded analysis on outside of bags, often prefer to give the percentage of ammonia rather than in nitrogen. It may give a better showing to put it five per cent ammonia instead of four per cent nitrogen; but the only proper way to put it would be, "four per cent nitrogen in ammonia" (or in nitrates, as the case may be), or leave out the source or form entirely, and simply say, "four per cent nitrogen." Then we know something about what we have before us.

Before going into the open market to look up our sources of supply, we should learn something of the character of the goods, and of the prices at which they may be purchased. These prices are subject to fluctuations, as are those of other articles of commerce, according to the disposition of the individual dealer, but chiefly in obedience to the laws of supply and demand. In recent years the tendency of

the prices of plant foods has in the main been downward, and favorable to the user. The recent discoveries of new and extensive deposits of phosphates in Florida and other points, and other circumstances, lead me to hope for a further reduction in the price of such phosphates, and perhaps also of nitrogen.

Some of the Agricultural Experiment Stations occasionally get together, and agree on a "Schedule of valuations" of plant foods, to serve as a basis for the determination of the value of any given fertilizer for a certain period of time. The rates thus agreed upon, however, often are considerably at variance with the manufacturers' actual average retail prices. A comparison of these with the stations' schedule of prices, both for the year 1890, is given in the following

TABLE OF VALUES:

SUBSTANCE.	Average Retail Price of	Valuation
	Manufacturers per pound.	adopted for 1890 by Stations per pound.
	cts.	cts.
Nitrogen from nitrate of soda, - -	14.2	14½
“ “ sulphate of ammonia, - -	16.9	17
“ “ dried blood, - - -	16.0	17
“ “ dried fish and ammonite,	14.1	17
“ “ cotton seed meal and castor pomace, - - -	12.8	15
Soluble phosphoric acid from bone black,	6.7	8
“ “ “ “ S. C. rock,	5.6	8
Reverted “ “ “ “ bone black,	6.7	8
“ “ “ “ S. C. rock,	5.6	8
Insoluble “ “ “ “ bone black,	1.7	2
“ “ “ “ S. C. rock,	1.4	2
Potash from high-grade sulphate. -	5.5	6
“ “ kainit, - - - -	5.0	4½
“ “ muriate, - - - -	4.2	4½

An inspection of the prices in the above table shows us that the market and the stations look at

the value of fertilizing materials from different standpoints. The dealer fixes the price, independent of the agricultural value of the article, with a view of making sales at a fair profit. The laws of supply and demand rule the market, and consequently the prices of the various substances of plant food not only fluctuate quite considerably, but there is also a wide difference between the prices of the same element as coming from different sources.

On the other hand, the stations—and with them the farmers—look only at the real fertilizing value of each substance, independent of the source from which it was obtained, or the price asked for it by the dealer. If a pound of nitrogen in sulphate of ammonia is worth eighteen and one-half cents, a pound in any other form, which would give us the same results, as it did in the other form, should be given the same valuation, even if the dealer asks a cent or two less for it. So it is with phosphoric acid. If soluble or reverted on one side, or insoluble on the other, it will give us the same practical results, pound for pound respectively, whether it is in the form of bone black, or of South Carolina rock; hence the agricultural value must be the same in either case, no matter how the price of the different forms may vary in the open market.

The stations' schedule give us a fair measure of *comparative* values, in an agricultural or practical sense. A comparison of market prices of fertilizing materials with the values as adopted by the stations will give us a clue to the solution of the problem, in what shape we may purchase our fertilizers most economically.

It hardly needs to be said that the *latest schedule* of values should in all cases be made to serve as a



basis of compilation. The valuations given in this work are based upon the prices found in the following table, viz.:

## SCHEDULE OF TRADE VALUES FOR 1891:

	Per lb.
Nitrogen in Ammonia Salts, - - - - -	18½c.
“ “ Nitrates, - - - - -	14½c.
Organic Nitrogen in dried and fine ground fish, meat and blood,	15½c.
“ “ “ castor pomace and cotton-seed meal, -	15c.
“ “ “ fine ground bone and tankage, -	15c.
“ “ “ fine-medium bone and tankage, -	12c.
“ “ “ medium bone and tankage, - -	9½c.
“ “ “ coarser bone and tankage - - -	7½c.
“ “ “ horn shavings, hair and coarse fish scrap,	7c.
Phosphoric Acid, soluble in water, - - - - -	8c.
“ “ “ “ ammonia citrate,* - - - - -	8c.
“ “ “ “ insoluble in dry ground fish, fine bone and t'k'ge,	7c.
“ “ “ “ fine-medium bone and tankage,	5½c.
“ “ “ “ medium bone and tankage,	4½c.
“ “ “ “ coarser bone and tankage,	3c.
“ “ “ “ in fine ground rock phosphate,	2c.
Potash as High-Grade Sulphate, and in forms free from Muriates (or Chlorides), - - - - -	5½c.
“ as Kainit, - - - - -	4½c.
“ as Muriate, - - - - -	4½c.

\* 7½ cents for Massachusetts, Connecticut and Pennsylvania.

## THIRTEENTH CHAPTER.

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### THE WORTH OF DOMESTIC MANURE.

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OUR MOST important source of plant foods, next to the soil itself, is barnyard or stable manure. This is a *complete* fertilizer, *i. e.*, one supplying all the needed elements of plant nutrition, in distinction from manures having only one or two of the three essential substances.

The value of stable manure is a somewhat uncertain quantity—very much like that of a pound of beefsteak, which may be from the round, and sell for eight or ten cents, or porter-house, and command twenty-five cents. The purchaser's own good judgment must in each case give the final decision concerning the price he can afford to pay.

The large range in the value of stable manure owing to different ways of feeding, to the state of preservation of the manures, and perhaps other causes, accounts for the wide variations found in the analysis and valuations of such manures given by the different Experiment Stations and agricultural chemists. The amount of the three chief substances of plant food contained in a ton of yard

manure is variously stated to be from eight to twelve pounds nitrogen, seven to ten pounds potash, and four to nine pounds of phosphoric acid.

A ton of fresh manure, consisting of the dry excrements of fairly-fed working horses and a little urine-soaked straw, contains about ten pounds of nitrogen, four pounds of phosphoric acid, and ten and one-half pounds of potash.

While we have no means of knowing in what exact degrees of solubility or availability the nitrogen, phosphoric acid and potash exists in stable manure, we may well suppose that all these plant foods will be utilized by our crops to the full extent that they are in our best concentrated fertilizers, only perhaps in a somewhat longer period. Consequently I feel justified in rating them pretty high.

At present prices of commercial fertilizing substances the value of a ton of this fresh horse manure may be computed as follows, viz.:

10	pounds nitrogen @ 17 cents,	-	-	-	\$1.50
4	" phosphoric acid @ 7 cents,	-	-	-	28
10½	" potash @ 4 cents,	-	-	-	42
	Total,	-	-	-	\$2.20

When we buy from manufacturers of concentrated fertilizers the same quantities of plant foods contained in the ton of fresh horse manure, we would perhaps have to pay three dollars for them. Hence if we can get a ton of fresh horse manure of the described quality at \$2.20, or less, without having to incur additional expense for hauling it, we make a better bargain than if we buy the average manufactured fertilizer at current rates.

Fresh cow manure varies but slightly from fresh horse manure in chemical composition. Hog and sheep manure may have a somewhat larger percent-

age of nitrogen, and perhaps also of phosphoric acid, but a smaller one of potash. On the whole we will not be far out of the way, if we concede to all these manures, when fresh, about an equal money value, ton for ton. Dry straw also differs but little from fresh manure in composition and fertilizing value. If used freely for bedding, and soaked through with urine, it will not lessen the value of the manure. Clear water adds to the weight, but nothing of fertilizing value, while urine adds also to the stock of nitrogen and phosphoric acid.

A heap of stable manure contains at no time a greater amount of plant foods than when first made. Nothing, so far as real fertilizing value is concerned, can be gained by storing or composting the manure. You may get it finer, and in better shape for more immediate use by the plants, but you do not add a particle of value to it by composting. If we wish to make use of every pound of plant food contained in the fresh stable manure, we must draw it to the fields as fast as made, and spread it at once.

In a series of experiments made at the Cornell University Experiment Station in 1889, it was found that horse manure, having been left outdoors in a loose pile for six months, had at the end of that time not only lost thirty per cent in weight, but that the resulting compost was reduced to the following amount of plant foods per ton, viz.:

9 pounds nitrogen @ 17 cents,	-	-	-	\$1.53
3 " phosphoric acid @ 7 cents,	-	-	-	21
6 " potash @ 4 cents,	-	-	-	24
				<hr/>
Total,	-	-	-	\$1.98

The greatest loss through fermentation and leaching, we see, is in the potash, and next in phosphoric

acid, while that in nitrogen (contrary to the old "escaping ammonia" theory) is comparatively slight. The compost, after all these losses, is still worth about two dollars, and therefore about twenty per cent less, ton for ton, than the fresh manure. The advantage of compost over the fresh manure, namely its fine mechanical condition, and perhaps the greater availability of its plant foods, has already been mentioned.

In deciding about the price which the user can afford to pay for any given sample of stable manure, he will have plenty of opportunity for the exercise of good judgment. Not only the quality and value of the manure itself, but also the cost of hauling must be taken in consideration. If it costs us one dollar to haul a ton from place of purchase to the field, we must not pay more than the figure representing its true value *less the dollar*.

In making estimates of the manurial values of stable manures, we may take fresh manure from well-fed horses or cows, consisting of dry excrement and urine-soaked litter, as a standard for comparison. A ton of such manure is worth, at current rates of plant food materials, in the vicinity of \$2.50, and even more when compared with prices of our commercial concentrated fertilizers. The higher the animals were fed—with grain, bran, oil meal, etc.—the more valuable is the manure. Animals that are merely "wintered"—just kept alive on a straw diet—give manure of much less value than animals that are being fattened or forced. Straw soaked full of rain or snow water, has probably not over one-half of the fertilizing value of good manure.

A ton of compost from manure exposed in a loose pile to the elements for months, which in its fresh

state had a fertilizing value of about \$2.50, is still worth about \$2.00; more, if from highly-fed animals, and kept under shelter, or otherwise well-preserved; less, if spread in thin layer and long exposed to leaching and soaking, or if originating from straw-fed animals, or if sawdust, soil or sand has been the only bedding material used.

The price asked by the seller of stable manures is rarely regulated by the quality or value of the article itself, but invariably by local conditions of supply and demand. It is rarely the case, that the buyer is required to pay a price approximating the real value of the article. Consequently good stable manure, where obtainable, is often or usually one of the very cheapest forms in which the farmer or gardener can procure the plant foods needed for his crops. Often one finds a real bonanza.

One of my neighbors, for instance, bought the past season in our immediate vicinity 100 two-horse loads of rotted cow manure for fifty dollars, or at the rate of fifty cents a load. He told me that he drew nearly three tons to the load, his span of horses being heavy and strong, and a rack being adjusted to the wagon box. The plant foods in such a fifty-cent load were probably worth over five dollars. Seeing his advantage he has since engaged all the manure the party has to sell, but there are other, fully or nearly as favorable chances to be found by the shrewd manure buyer in many localities.

In some places fifty cents is asked for a "load," in others the ruling price is one dollar, seldom more, but the size of the load is usually left to the discretion of the purchaser who may put on all that his horse or horses can draw. Here again is considerable latitude for good judgment, both in making the

bargain, and in loading and hauling the manure. If a "load" is sold at a certain price, with the understanding that "load" means all that the buyer's team can draw, it is the buyer's privilege to keep strong, well-fed horses, and well-greased capacious wagons, and to pick out a time of good roads for the job of hauling. Usually manure can be bought cheaper by the two or three horse load than by the one-horse load, for the one horse draws half wagon and half manure, while each additional horse concentrates his strength upon pulling manure.

How can the manure be measured? The manure-buying farmer is usually an expert in estimating the weight of his load. A span of ordinary 1,000 lb. horses, as usually kept in our rolling sections, and on roads by no means too good, can just handle a 2,000 lb. load on wheels with comparative ease, while two tons or over are not too much for heavy horses on smooth, nearly level roads. More can be loaded and easily hauled on good sleighing.

The bulk of the manure must of course be the chief guide in estimating its weight. A cord of average barnyard manure (128 cubic feet) weighs about 4,500 pounds, so that a ton of such manure contains about fifty-seven cubic feet. To estimate the weight of a pile of manure, multiply the figures representing average length, width and height, and divide by fifty-seven. This will give you the number of tons in the heap. A wagon or sleigh box twelve feet long and three feet wide, loaded with manure nearly two feet high (allowing for loose packing) contains a good plump ton—more, if the manure is wet and compact, less perhaps, it consisting largely of dry coarse litter.

In the computation of the commercial value of

stable manure, no account could be taken of the carbon in it. Yet this constituent gives a great additional advantage over concentrated or chemical manures, which supply the three essential plant foods, but have not the beneficial mechanical effect to be observed from the decomposition (slow combustion) of the carbonaceous matter contained in the barnyard manures.

Not all farmers, however, have such golden opportunities of purchasing manures at rates such as named. The rest may have to patronize the manufacturers or mixers of concentrated manures, or they may become manufacturers of fertilizers themselves, by keeping and raising more stock—cows, sheep, hogs, poultry, etc.—at the same time making a home market for a large share of their products, since high feeding is as necessary a condition of success in this branch of agriculture, as high cultivation is in profitable grain and fruit farming.

Next to ordinary stable or barnyard manure, poultry droppings may justly be considered the most important of the domestic farm fertilizers.

**Poultry  
Manure.**

I am in receipt of more inquiries concerning the value of poultry manure, than concerning that of any other fertilizer, wood ashes perhaps excepted. At the same time there is a good deal of rubbish written about its great value, and its caustic nature, and so forth, so that people have largely overestimated its strength, and become afraid to apply one quarter of a fair ration for fear of hurting the crops.

Poultry droppings, like other yard manures, vary greatly in value, according to kind and amount of feed given to the fowls, and the treatment given to the droppings. A fair average sample of the ma-



terial (allowed to accumulate under the sheltered roosts, and mixed with the little dry soil or coal ashes used as absorbent) contains about eighteen pounds of nitrogen, twelve pounds of phosphoric acid, and eight pounds of potash per ton. In computing the approximate value of the article, we have

18 pounds nitrogen @ 17 cents,	-	-	\$3.06
12 " phosphoric acid @ 7 cents,	-	-	84
8 " potash @ 4 cents,	-	-	32
Total, per 2000 lbs.,	-	-	<u>\$4.22</u>

Compared with the price of the best commercial fertilizers, this quality of hen manure will have an agricultural value of nearly five dollars per ton, and other samples, if dry and well kept, may be worth still more. The buyer of fertilizers can well afford to pay twenty or twenty-five cents for each 100 pounds of average well-kept poultry manure. If largely mixed with litter, soil, coal ashes, etc., or when very wet, or when wood ashes were freely used as an absorbent, so that a part of the ammonia is driven off, its true value may be much less.

Analysis shows poultry manure to be especially rich in nitrogen, and this is in the right shape to become gradually available as the plants may need it. Therefore instead of mixing it with other stable manures, although this may be a good practice for ordinary farm purposes, I greatly prefer to keep it separate, and to apply it for special purposes, for instance as a top dressing in the garden, for onions, spinach, celery plants, etc.

At the same time the analysis makes it plain that we need not be so very much afraid of applying it pretty freely, if we apply it evenly.

## FOURTEENTH CHAPTER.

### VALUE OF OTHER DOMESTIC MANURES.

“ I HAVE an opportunity to buy unleached wood ashes at ten cents per bushel. Will it pay me to draw it two or three miles for use as a fertilizer? That is a sample of the many letters received annually by editors and publishers of agricultural journals. It shows that the great value of wood ashes as a fertilizer is not yet generally recognized. Like farm-yard manure, poultry droppings, or other manurial substances, different samples of wood ashes vary very greatly in the percentage of their manurial constituents, and consequently in their value. A fair average sample of home-made ashes, made from hickory, beech, maple and hard oak, etc., contains about seven per cent of potash and two per cent of phosphoric acid, and at current retail prices of plant foods, is worth as follows:

7 pounds potash @ 5½ cents,	-	-	38½ cents.
2 “ phosphoric acid @ 8 cents,	-	-	16 cents.
Total, per 100 pounds,	-	-	54½ cents.

Or \$10.90 per ton. Potash (which element represents the chief value of ashes) exists here in a

readily soluble form, and thus is immediately available for plant food. This accounts for the prompt, and often astonishing effect that applications of wood ashes usually have upon plant growth, and justifies us in placing the value of this fertilizer much above the result of mere multiplication and addition on the basis of the analysis. The farmer can better afford to pay fifteen dollars per ton for wood ashes answering the above analysis than the usual rates for almost any commercial fertilizer.

The variation in quality, of course, must be taken into account. The value of home-made, hard-wood ashes, preserved in best condition, is often much above fifteen dollars, and if corn cobs are largely used for kindling, or summer fuel, the ashes may reach twenty dollars per ton in value. On the other hand, by far the greater part of purchasable wood ashes are worth less. If made from soft wood, and subjected to more or less exposure, especially leaching, etc., the value of a ton may not be more than five dollars.

Leached ashes have rarely more than one and one half per cent of phosphoric acid and one per cent of potash, and are worth per 100 pounds :

1½ pounds phosphoric acid @ 8 cents,	-	12 cents.
1    "    potash @ 5½ cents,	- . . . -	5½ cents.
Total,	- . . . -	17½ cents.

or \$3.50 per ton, five dollars being about the limit that the farmer could afford to pay, and this only if near by. In buying ashes, especially in coming to a conclusion concerning the question,

**Leached Ashes.**

“How much can I afford to pay for a certain lot?” there is considerable latitude for the exercise of good judgment again. But no intelligent person need be deceived. An examina-

tion of the goods will give some idea of their quality, and particularly show very plainly whether the ashes are leached or not, wet or dry, etc. This with a knowledge of the surrounding circumstances (generally they are known or can be easily inquired into), and especially of the source of the ashes, will be all the evidence needed in the case. But if I could buy a lot of unleached hard-wood ashes, of average quality, at ten cents per bushel, or even at fifteen cents, I would not hesitate to buy all I could draw, even if I had to go four or five miles after them.

Canada ashes are largely advertised by various parties. Sometimes they do not come up to the mark. More generally they analyze about five and half pounds of potash, and two pounds of phosphoric acid (more or less of each—oftener less than more) hence their value may be estimated as follows:

5½ pounds potash @ 5½ cents,	-	-	30 cents.
2 " phosphoric acid @ 8 cents,	-	-	16 cents.
Total, per 100 pounds,			46 cents.

or \$9.70 per ton. We can afford to pay about twelve dollars, perhaps thirteen or fourteen dollars per ton. This is their value for the manure-buying farmer. The gardener and fruit grower may sometimes, for special purposes, go even beyond the largest figures named. There is only one precaution which I have to add. Wood ashes, under average conditions, should not be mixed with other manures, especially not with poultry manure. The worst possible use that could be made of them is to scatter them under the roosts in the poultry-house. A mixture of the two substances without the free use of soil or other absorbents, can only serve to reduce

**Canada  
Ashes.**

the value of both. The potash of the ashes (then in the most available form) tears the ammonia of the manure from its combination, changes itself to a less desirable form, and the ammonia to the volatile carbonate of ammonia—and away this latter goes, lost to the owner, and working mischief among the fowls roosting just above where the injurious vapors are generated. Unless you have a special object in view, always apply the ashes to the soil, unmixed.

The ashes of both soft and hard coal contain little more than traces of potash and phosphoric acid, and as plant food are probably worth considerably less than fifty cents per ton. For stiff clay soils, however, they usually have a desirable loosening effect, and as a top dressing and mulch, especially in fruit gardens, etc., they are very beneficial. Still, I think the best use that can be made of them is to sift and put them under the hen-roosts as absorbents, or use them in a similar way in stables or privies. Sifted coal ashes absorb liquids, fix volatile ammonia, and prevent offensive odors.

**Coal Ashes.**

Cotton-seed hull ashes are available in many sections, and not only a most valuable and highly concentrated fertilizer, but usually a very cheap one, also. A fair average of a number of analysis gives to this material about twenty-five per cent of potash and ten per cent of phosphoric acid. I would make an estimate of its value as follows:

**Cotton-seed  
Hull Ashes.**

25 pounds potash @ 5½ cents,	-	-	-	\$1.37½
10 pounds phosphoric acid @ at 8 cents,	.	.	.	80
Total, per 100 pounds,				\$2.17½

or \$43.50 per ton, and we could well afford to pay fifty dollars for it; and no tiller of the soil should

neglect to make liberal use of it, whenever it is offered at a lower rate, and needed.

I find a valuable addition to the stock of domestic fertilizing materials in the results of what has fitly

**The Rubbish  
Roast.**

been termed the "annual roast of rubbish." The great spring cleaning—in doors and out—accumulates a large amount of waste materials, such as brush, rotten wood and rails, chips, sawdust, weeds, leaves, wet straw, old bones, old boots and shoes, rags, old papers, old mortar, perhaps oyster and clam shells, and other unsightly things, too numerous to mention, that have outlived their usefulness. To get rid of all this stuff is worth something, and it may be disposed of in a way both convenient and useful.

I practice the following plan: First I select a spot suitable for the great autotafe, usually back of the house, and far enough away from the buildings for safety. Here I lay a foundation of rotten rails, timbers, or anything of a woody nature that is of no value for other purposes, and upon this I start my fire. The trimmings of the orchard trees, and bush fruits, etc., are piled on next, until the fire is going briskly. Then come the yard rakings and the house sweepings, chips, wet sawdust, corn cobs, wet leaves, grass and weeds, with what old bones, clam and oyster-shells may be on hand, or a small quantity of lime stone, also wet straw, old sods, and anything else of a similar nature. The rakings and sweepings are usually quite damp and mixed with wet soil, etc., and should be spread pretty evenly over the roasting heap so that the fire is merely glowing underneath an outside covering, not blazing up in open flame.

The entire mass may thus remain glowing and

glimmering away for several days and nights, perhaps for weeks, and left thus until the stuff is wanted as a top dressing for the garden. Exposure to air and rains will slake the caustic lime. The ultimate result of the cremation process is a heap of dust-like material, consisting of ashes, charcoal and loam, all strongly flavored with creosote, and for that reason very repulsive to insect foes. This, however, gives it only an additional value. The material has, of course, considerable potash, some lime, and perhaps phosphoric acid (from the bones).

As ordinarily managed, the matter deposited in privy vaults is allowed to poison the air, soil, and perhaps the well-water to become a stench in our nostrils, a constant source of danger to health, and a nuisance generally, while it could easily be rendered entirely inoffensive to the most sensitive person with the most squeamish stomach, and made to add considerably to our stock of farm manures.

**Closest  
Contents.**

The first thing to do is to stop digging vaults, or to fill them up where already dug. Have the privy high and dry, in a well-protected situation. Use large stout buckets with strong handles under the seat, or still better a wheelbarrow with sheet iron box. A small scoopful of dry muck, dry loam, or sifted coal ashes should be thrown into the receptacle by each person immediately after leaving the seat, and the buckets or wheelbarrow should be emptied upon the compost heap regularly once or twice a week. This will increase the manure heap quite considerably both in quantity and quality.

## FIFTEENTH CHAPTER.

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### THE CONCENTRATED COMPLETE MANURES.

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OUR modern system of cropping is taking the plant foods from the soil much faster than we are able to return them by the application of barnyard manure, hen droppings, muck or peat, and all the other sources of fertility commonly within reach of the average farmer. This observation, and the recognized need of a greater supply of plant foods have led to the search for other sources, to the impregnation of various substances suitable for this purpose, and finally to the manufacture of our modern so-called "concentrated commercial" fertilizers.

There is as wide a difference between commercial fertilizers as there is between sand and manure, or between sugar and salt, or between a tender, juicy, tenderloin steak and the sole of a old boot. Buying and applying concentrated fertilizers promiscuously, without having the least idea what they contain, or what the soil needs, is little better than taking chances in a lottery. While full information on all these points can be obtained so easily, by any



farmer who desires it, there is no need of this "going it blind."

In compounding the various concentrated fertilizers, all sorts of materials are made use of—fish, bone, blood, slaughter-house refuse, phosphate rock, guano, potash salts, nitrates, sulphate of ammonia, and many other things—and manufacturers are always on the lookout for everything available for this purpose, and purchasable at a reasonable price. As a result of all this, and of different ways of preparation, and different proportions in mixing, etc., we have the thousand and one different brands, in different degrees of strength and composition, for general and special purposes, and of different prices, from twenty, or less, to forty-five dollars and upwards per ton.

**High Grade  
vs. Low Grade  
Fertilizers.**

These fertilizer men have superior facilities for purchasing, preparing and mixing the ingredients, and their professional skill enables them to make these materials most readily available and effective. At the same time there is competition enough that we might think it would keep the selling price of honest fertilizers down to within just a little above the line where the business barely pays its own expenses. One of the prominent eastern fertilizer manufacturers recently, in public, declared his willingness to give to anybody who would guarantee him a clear profit of two dollars per ton on his goods, all the income above that limit. This profit, even though it secures the company a fine income, is, however, not larger than the farmer can well afford to pay to the manufacturer for a high-grade article.

But I cannot warn too strongly against the low-grade, so-called "cheap" fertilizers. They are not

profitable to buy, especially if they have to be freighted any considerable distance.

The manufacturer has to charge for all the goods that he delivers at buyer's nearest station:

(1) Retail price of the plant foods, as given in the schedule of prices previously mentioned.

(2) Cost of preparing and mixing these raw materials, and of storing and handling the goods.

(3) Cost of bags, barrels, etc., and putting up in ship-shape.

(4) Freight, cartage, etc.

For a number of years I have used a special potato manure with most gratifying results. This is a "high-grade" mixture, containing about four per cent nitrogen, twelve and half per cent phosphoric acid, and six per cent potash. Now suppose we wish to buy 80 pounds of nitrogen, 250 pounds of phosphoric acid and 120 pounds of potash, which is just about the quantity contained in one ton of a high-grade potato manure. Computed at schedule rates, this quantity of plant foods, in the form they appear in the potato manure (partly soluble and partly not), would have a chemical value of about thirty-four or thirty-five dollars. To this, the manufacturer adds expense of handling, mixing, bagging, carting, freighting—and perhaps something for profit—charging about forty-two dollars per ton, or an advance of about seven or eight dollars per ton, or somewhat over twenty per cent of the value of the raw materials.

Another manufacturer might offer us a low-grade or "cheap" fertilizer having just one-half of the percentages of plant foods contained in this potato manure. To get the same quantities of the food elements, two tons of the cheaper kind would be re-

quired, and the manufacturer would have to charge

(1) for nitrogen, phosphoric acid and potash, -	\$35.00
(2) mixing, handling, bagging, etc., 2 tons @ \$7.15 -	15.00
Total, - - - - -	<u>\$50.00</u>

or an advance on cost of raw materials of over forty per cent, and in most cases still more. Besides this you find your own labor in drawing, handling and application increased to just double the amount needed for the other. I think this will show you plain enough that your only safety lies in the use of high-grade manures if you buy any of them. The cheap goods are too dear, after all.

Manufacturers in eastern states are legally required to print on each bag or barrel a guaranteed analysis of the goods contained in it, if they sell at a higher price than ten dollars per ton. Usually fertilizers come fully up to the guaranteed standard, and often they go above it.

**Safeguards  
Against  
Imposition.**

Before we purchase any fertilizer, we should know its real value. Suppose we have a brand offered us under the following guaranteed analysis, as printed on the bags or barrels:

Nitrogen in ammonia, - - -	3 to 4 per cent.
Soluble phosphoric acid, - - -	6 to 8 " "
Insoluble " " - - -	2 to 3 " "
Total " " - - -	8 to 11 " "
Potash (sulphate), - - -	8 to 10 " "

Taking the lower figures as a basis for our calculation, we find in each 100 pounds of fertilizer:

3 pounds nitrogen @ 18½ cents, - - -	55½
6 " soluble phosphoric acid @ 8 cents, - - -	48
2 " insoluble " " @ 2 cents, - - -	4
8 " potash, @ 5½ cents, - - -	44
Total, - - - - -	<u>\$1.51½</u>

or in one ton (2000 pounds) twenty times \$1.51½, or

\$30.20 worth of raw materials. On the basis of the higher figures, we find in each 100 pounds:

4 pounds nitrogen @ 18½ cents,	-	-	-	74
8 " soluble phosphoric acid @ 8 cents,	-	-	-	64
3 " insoluble " " @ 2 cents,	-	-	-	6
10 " potash @ 5½ cents,	-	-	-	55
Total,	-	-	-	<u>\$1.99</u>

or in one ton (2000 pounds) 20 times \$1.89, or \$39.80. Thus we see that the value of the raw materials in such high-grade fertilizer may vary between \$30.20 and \$39.80. The goods of our reputable fertilizer firms usually come near the higher figure, and in many cases they go even above it. Add to this the various expenses of manufacturing and selling, and the price of a fertilizer with guaranteed analyses as the one in consideration can hardly be expected to be much below forty dollars per ton.

If we examine a fertilizer on the packages of which we find guaranteed analyses as follows, viz:

Nitrogen,	-	-	-	-	1 to 2 per cent.
Available phosphoric acid,	-	-	-	-	6 to 8 " "
Insoluble " " "	-	-	-	-	2 to 3 " "
Total,	-	-	-	-	8 to 10 " "
Potash,	-	-	-	-	2 to 4 " "

we may make the following estimate of its chemical value (value of the raw materials of plant food at retail) per 100 pounds, viz.:

*1. Based on lower figures of analyses:*

Nitrogen, 1 pound @ 18½ cents,	-	-	-	18½
Phosphoric acid, available 6 pounds @ 8 cents,	-	-	-	48
" " insoluble 2 pounds @ 2 cents,	-	-	-	4
Potash (probably muriate) 2 pounds @ 4½ cents,	-	-	-	9
Total,	-	-	-	<u>79½¢</u>

or per ton,  $20 \times 79\frac{1}{2}$  cts. equal to \$15.90. The valuation on this basis would perhaps not be fair to the

manufacturer. Often the percentages reach and even exceed the higher figures of the analysis.

*2. Based on the higher figures:*

Nitrogen 2 pounds @ 18½,	-	-	-	-	37
Phosphoric acid, available 8 pounds @ 8 cents,	-	-	-	-	64
“ “ insoluble 3 pounds @ 2 cents,	-	-	-	-	6
Potash 4 pounds @ 4½ cents,	-	-	-	-	18
Total,	-	-	-	-	<u>\$1.25</u>

or per ton  $20 \times \$1.22$ , equal to \$25.00. Thus we find that its value is somewhat between \$15.90 and \$25.00, probably near \$20.00. Such a fertilizer usually sells for thirty to thirty-two dollars, although it may be dear at twenty-five dollars. It certainly is not a “high-grade” manure, nor even a well-balanced one, and while perhaps suitable for soils which are more in need of phosphoric acid than of the other two substances of plant food, is hardly safe for general crops on soils lacking all three substances. ✓

Of course, we desire still safer guarantees than the mere printed analyses on the bags and barrels of fertilizers, and such guarantees and full information generally, are at the farmer’s disposal without money and without price, merely for the asking.

**Experiment  
Station  
Analyses.**

The various state experiment stations forward free to applicants in their own state their bulletins containing, besides other valuable information, the fertilizer analyses as they are made from time to time for the very purpose of letting farmers know the doings of fertilizer manufacturers. These analyses, by the way, are also a most wholesome method of supervision and to enforce honesty in compounding the manures. Every open fraud is soon detected and shown up. The percentages of the substances of plant food in many, perhaps the majority of all

manufactured fertilizers are found to be larger than indicated by the makers' own printed analyses. Frauds are occasionally attempted, but the intelligent and careful farmer need not allow himself to be swindled.

Some of the experiment stations, as for instance that of New Jersey, not only give the analyses in great detail, but also save us the work of figuring out the values, etc., of analyzed fertilizers. These tables have a column marked "Value of 2000 pounds at station prices." The figures in this express the value of the three substances of plant food in each fertilizer, computed on the basis of the prices at which the ingredients could be bought at retail for cash in our large markets (in the raw materials which are the regular source of supply). The other column gives us "the selling price of 2000 pounds at consumer's depot." For this no further explanation is needed.

From a table of analyses found in a recent bulletin of the New Jersey Experiment Station, I take the following figures representing analyses of a certain potato manure:

Nitrogen from nitrates,	-	-	-	-	0.83
"    from ammonia salts,	-	-	-	-	1.54
"    from organic matter,	-	-	-	-	1.89
<b>Total found,</b>	-	-	-	-	<b>4.26</b>
<b>Total guaranteed,</b>	-	-	-	-	<b>3.69</b>
Phosphoric acid soluble in water,	-	-	-	-	3.95
"    "    "    in ammonium citrate,	-	-	-	-	5.82
"    "    insoluble,	-	-	-	-	3.35
"    " <b>Total found,</b>	-	-	-	-	<b>13.12</b>
"    " <b>Total guaranteed,</b>	-	-	-	-	-
"    " <b>Available, found,</b>	-	-	-	-	<b>9.77</b>
"    "    " <b>Guaranteed,</b>	-	-	-	-	<b>8.00</b>
<b>Potash found,</b>	-	-	-	-	<b>7.19</b>
" <b>Guaranteed,</b>	-	-	-	-	<b>6.00</b>
Chlorine,	-	-	-	-	0.71

The next three columns give the valuations, which, of course, are subject to variations according to market prices of the raw materials and manufactured fertilizer, etc. In computing the value of the fertilizer from these figures we have the following:

Nitrogen from nitrates	0.83 pounds @ 14½ cents,	\$12.03½ cts.
“ from ammonia salts	1.54 pounds @ 18½ cts,	28.49 “
“ from organic matter	1.89 pounds @ 15½ cts,	29.29½ “
Phosphoric acid soluble in water	3.95 pounds @ 8 cts,	31.61 “
“ “ “ in ammonium citrate (revert-		“
ed	5.82 pounds @ 8 cents,	46.56 “
Phosphoric acid insoluble	3.35 pounds @ 2 cents,	6.70 “
Potash (sulphate)	7.19 pounds @ 5½,	39.54 “
		<hr/>
Total, per 100 pounds,	- -	\$1.9421½

or in 2000 pounds  $20 \times \$1.9421\frac{1}{2} = \$38.84\frac{3}{10}$ .

To this amount the legitimate expenses for mixing, bagging, transportation, etc., have to be added, so that at present trade values we cannot expect to buy this fertilizer at much if any less than forty-five dollars per ton.

In explanation of my figuring I have yet to make the following statements: Nitrogen from organic matter was figured at eighteen and one-half cents per pound, in the assumption that it was derived from dry and fine-ground meat and blood, bones, or equally good forms of animal matter, and not from leather, shoddy, hair, or any low-priced, inferior form of vegetable matter. As we have no way of telling, by analysis, whether this nitrogen is readily available for the use of plants or not, this assumption is largely a matter of confidence in the integrity of the manufacturer, and based upon the general good results reported by the users of such fertilizer. Reputable firms, that intend to do business permanently, cannot afford to use the inferior articles

named as source of organic nitrogen in their goods. Phosphoric acid soluble in ammonium citrate is the so-called "reverted" phosphoric acid. It belongs to the "available" class, in so far as plants readily assimilate it, and we concede to it a value of eight cents per pound, same as to phosphoric acid soluble in water. Some stations, notably those of Massachusetts, Connecticut and Pennsylvania, only consider it worth seven and half cents. The insoluble phosphoric acid is valued only at two cents a pound, and I think this is all it deserves, although some stations figure it at three cents or more, in the assumption that it is from bone or similar sources, and worth more than that from rock phosphate.

The small percentage of chlorine shows the potash source to be sulphate, worth five and one-half cents per pound. The peach tree fertilizer made by the same firm has 4.27 per cent chlorine. Here we have the potash evidently in the muriate form, and for this reason would value it only at four and one-half cents per pound. Chlorine makes the application of excessive doses of muriate (chloride) of potash risky for many crops. Its absence shows that a manure has derived its supply of potash from sources other than muriate; for instance, from sulphate, nitrate, or carbonate of potash.

The analyses of fertilizers published in the station bulletins are not all arranged exactly like those of the New Jersey station. At any rate, however, they give us a clue to the computation of the approximate values of such fertilizers.



## SIXTEENTH CHAPTER.

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### WHERE CAN WE GET OUR NITROGEN?

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**B**ESIDES the complete manures considered in the foregoing chapters, there are an endless number of other substances available for manurial purposes, and many of these are often a much cheaper source of plant food, in certain localities, than either the city stable manure, or the concentrated manures found in our markets. Some of these substances contain only a single element of the three chief ones under consideration, others have a combination of two, others are perhaps complete, but more or less one-sided; and altogether there is choice enough, so that we can purchase just what element, or combination of elements we may need, without having to buy one we do not want or require.

We will try to ascertain the true value of the leading substances available for these purposes.

As stated once before, tons and tons of nitrogen, in an uncombined and free elementary state, only

mixed with oxygen, rest upon every acre. This is many hundred times as much as any crop could use, if it were in the proper form for plant food, which it is not. A considerable amount of speculation has been wasted on this subject. Here we have the two elements in greatest abundance, which combined, are so expensive to procure, and which are just what our soils need to make them rich; and if we could induce the two free elements to enter into a chemical union, at little cost to ourselves, we would have no need of going to South America for nitrate of soda and saltpetre, nor be concerned about where to get nitrogenous fertilizers. The material is on hand, and yet we cannot get it in shape for the use of plants.

**Nitrogen  
from the Air.**

There are analogous instances in our relations with chemistry. In water we have an inexhaustible supply of a chemical compound which, if we could but separate the chemical union, at little cost, and get the two elements, hydrogen and oxygen in their free, elementary state, would give us fuel and light much more powerful than coal or gas. Here again we have free access to the materials, and yet we cannot utilize them with economy, merely because the separation of the two elements would require the same energy that they produce, and no more.

We also know that the chemical combination of hydrogen, oxygen, nitrogen and carbon, in certain proportions, with a little seasoning of sulphur, phosphorus and other elements, gives us our steak for our breakfast, the mutton chops or fish for our dinner, and the cake for our tea; and while all these elementary materials are plentiful in nature, we would soon starve if we had to depend on making the combination in an artificial way. It is a pity

that our knowledge and powers are so limited, but we have to take things as we find them.

It has been found, however, that Nature does contribute a small amount to the nitrogen fund of the soil; and this, although too little for any perceptible effect on our crops, is perhaps enough to slowly improve a poor piece of ground, when left uncropped.

The ammonia escaping from different sources diffuses itself through the atmosphere; nitric acid is formed by the electric spark passing through the air during thunder showers. The rains absorb it and carry it down to the ground. It is then utilized by plant growth, or washed into the streams.

This free contribution of nitrogen from the air may help the poor owner or tiller of poor soil to continue his unprofitable style of poor farming until it lands him in the poor-house; but it is by far too miserly to be of much use to the good farmer whose crops are provided with liberal rations of nitrogen by the free use of manures, and who, consequently, has large and paying yields.

I do not know but what it would be just as well, practically, to forget entirely that nature grants us this pitiful allowance, and to depend altogether on our own facilities for supplying the soil with the needed nitrogen in one of the various forms of nitrogenous manures.

There is one way, however, in which we can draw on the nitrogen supply of the air, and make it available at least to some extent. This is by means of clovers and other leguminosæ, which seem to have the power of deriving their nitrogen from the air, when they cannot get it from the soil or subsoil. Of this I will speak in a later chapter.

In nitrate of soda we probably have the cheapest

source of commercial nitrogen, and a very valuable one besides. The chief point from which this nitrate is obtained is Iquique, Chili. There is an export duty on it of ten dollars per ton. Vast beds extend for two or three hundred miles along the west coast of South America. These beds are supposed to have been formed by decomposing sea-weed. It is yet comparatively little used in this country, and the present demand for it is so limited that not a pound of the cheaper grade—which strictly is the fertilizer nitrate—is imported to the United States, while progressive growers in Europe consume a hundred thousand tons or more a year.

**Nitrate  
of Soda.**

The nitrate imported to this country is shipped in bags holding about three hundred pounds each. A chemically pure sample, as we have seen in Ninth Chapter, or might again figure out from the chemical symbol  $\text{Na NO}_3$  and the table of atomic weights, (see page 49) has 16.47 per cent of nitrogen. It takes a pretty good sample of the salt as imported to give us sixteen per cent, or 320 pounds to the ton. The commercial value of this nitrogen, at the present time, is fourteen and half cents per pound, which would make a ton worth \$46.60. It is said that the article can be adulterated—for instance, with additions of white sand, or of cheap potash salts. But every buyer can easily examine the stuff upon its purity. See if it all perfectly dissolves in water. If so, it is free from sand. Then taste the solution, and if this has no distinct salty taste, you may be sure there is no cheap potash salt in it.

Now, when we are thus assured of having the genuine article, we may also feel certain that every ounce of this nitrogen is ready for immediate use by

plants. We understand (or have the means to learn to understand) its true nature and habits, and have no need of putting our reliance on uncertainties and guess work—a most important advantage, not possessed by nitrogen in other forms, as in farm manures, muck, and even in the commercial concentrated fertilizers. The chemist cannot always determine how much of the nitrogen in such materials is available, and how much is not. The most he can do is to tell us the amount of ammonia in the goods, but not whether any or all of it is in condition to feed plants or not. This is an element of uncertainty which to me is terribly annoying. It also affords protection to the manufacturer of poor, but high-rated fertilizers, which are making a good showing only in analysis, a protection which helps him to palm off low-grade stuff on the farmer (who buys it on strength of its high analysis published in station reports) without fear of immediate detection.

Whenever we wish to apply nitrogen to our crops in the usual forms, we meet this difficulty, this element of uncertainty. The use of nitrates, especially nitrate of soda, alone can deliver us from this annoying and perplexing feature. It enables us to reckon with definite figures. No sham or cheat about it. We know what we have and apply it. For this very reason its uses gives us so much satisfaction.

Another nitrate form of nitrogen is saltpetre, and a very valuable one besides, of quick and often even more marked effects than the preceding, but too expensive for general purposes of crop feeding. Saltpetre, like nitrate of soda, is imported from South America, but nitrogen is not its only valuable constituent; it has potash also, being a nitrate of

**Saltpetre or  
Nitrate of Potash.**

potash. The only thing that might come in consideration here is the saltpetre waste of gunpowder works, but this contains much more potash than nitrogen. It analyzes about two per cent of nitrogen, and twenty per cent of potash, and is worth at station prices almost \$1.50 per 100 pounds or \$30 per ton.

In sulphate of ammonia we have a valuable by-product of the gas works. It looks somewhat like fine salt, and not being quite so ready to absorb moisture and melt away, or to form large solid

**Ammonia.** chunks that have to be broken up, like nitrate of soda, is much more convenient to keep on hand, or to handle, or to mix with other fertilizing substances. I have sometimes used it on vegetables, and often thought it gave me just as good results as the nitrate of soda. An average sample contains twenty per cent of nitrogen, and this is rated in the station schedules at eighteen and one-half cents per pound, so that 400 pounds contained in a ton make it worth \$74.50. Its nitrogen, although not as readily available, is held by the soil, and thus saved for plant growth, while any excess of nitrogen in nitrates would at once try to make good its escape down into the soil water and perhaps into the drains, to be carried away to river or sea.

Among other sources of nitrogen, cotton seed and cotton-seed meal are probably in the front rank, especially as these substances are accessible to farmers in many localities where

**Cotton Seed  
Meal, etc.**

nitrate of soda, sulphate of ammonia and similar nitrogen compounds are either not readily obtainable or too costly in consequence of exorbitant transportation charges. I admit that the nitrogen in cotton-seed meal is not quite as readily

available as that of nitrate of soda or sulphate of ammonia, but it is in a pretty good shape. Besides this element, cotton-seed meal also contains a small percentage each of potash and phosphoric acid. An average of a number of analyses concedes to it 6.80 per cent nitrogen, 1.35 per cent phosphoric acid, and 1.20 per cent potash. Its nitrogen is rated by the stations at fifteen cents per pound. One hundred pounds of cotton-seed meal has the following fertilizing value, namely:

6.80 pounds nitrogen @ 15 cents,	-	-	\$1.02
1.35 " phosphoric acid @ 6 cents,	-	-	08
1.25 " potash @ 5 cents,	-	-	06
Total,	-	-	<u>\$1.16</u>

which makes the ton, at station rates, worth \$23.20. Hence at twenty-eight to thirty dollars per ton it would be about as cheap as the ordinary concentrated fertilizer at manufacturer's prices.

Castor pomace is very similar to cotton-seed meal in composition and effect. It contains a little less nitrogen, however, and a little more potash and phosphoric acid. Its value per 100 pounds is about as follows :

5.60 pounds nitrogen, @ 15 cents,	-	-	\$0.84
2.00 " phosphoric acid @ 6 cents	-	-	12
1.40 " potash @ 5 cents,	-	-	07
Total, per 100 pounds,	-	-	<u>\$1.03</u>

or \$20.60 per ton. We could well afford to give twenty-five dollars per ton for it.

Linseed meal contains the three plant foods in about the same proportion as castor pomace, and its schedule value does not vary much from \$20.

Agricultural papers and their staff of writers have a curious habit. When asked by their readers (as

frequently happens) about the fertilizing value of oil meal, bran, etc., the answers usually and truthfully state that such materials are excellent fertilizers, and frequently can be obtained much cheaper, proportionately, than regular manufactured concentrated manures. The advice, however, is invariably added, to use them as food for cattle or other stock first, and (what is left after having passed through the stock) for plant food next. Animals assimilate about twenty per cent of plant foods in the meal, and pass eighty per cent into the manure pile. If the meal was bought at a reasonable price, the twenty per cent transformed in animal flesh and bone might pay more than the cost of the whole, and the eighty per cent increase the value of the manure sufficiently to pay the cost of the whole a second time. This may be good logic, but I take it for granted that any farmer progressive enough to seek information about the cheapest available sources of plant food, with the intention of drawing on them, is also intelligent enough to feed his stock properly. He already gives them all that is good for them, and that he is satisfied will keep them in best possible condition for his purposes. He crowds his fattening stock all that he dares to. What more can he do? To stuff horses, cattle and sheep above what is best for them, merely for the sake of making the manure richer, would be the height of folly. In short, the inquirer and recipient of this advice was in search of plant food, not for food for his stock. Whether it is advisable for him to apply cotton-seed meal, linseed meal, bran, etc., directly to his soil or not, depends wholly on the price at which these goods can be purchased in your available market.



If my soils needs nitrogen, or the manure at my disposal does not contain as much of the element as I think would be desirable for my purposes, and I can buy nitrogen in the form of cotton-seed meal cheaper than in any other forms (say at twenty dollars or little more per ton), I would not hesitate a minute to apply it directly to the soil broadcast. Or, if my land needs phosphoric acid, and I can buy it cheaper in the form of wheat bran than in any other (say at twelve to fourteen dollars per ton), why in the name of common sense should I refuse to apply it? The price alone must decide this question.

People who ask questions of this character usually have in view the immediate use of the articles they inquire about for fertilizing purposes. They cannot be expected to procure a lot of stock to which the meal and bran, etc., might be fed, and to go all through this slow process, and then have for their pains a lot of raw manure which in turn has to be composted, etc. Life is too short for all this. We will take the plant foods wherever we can get them the cheapest, and apply them for immediate use.

Dried blood is another important nitrogenous fertilizer. It often contains as high as eleven per cent nitrogen, valued at fifteen and one-half cents per pound. Besides this it has a few per cent of phosphoric acid, and altogether its valuation comes very near to forty dollars per ton. It is very effective and quick-acting manure. Dried flesh, with twelve per cent nitrogen and two per cent phosphoric acid, is even more valuable than dried blood, and fifty dollars is not too much to pay for it. Dry, ground fish, containing eight to nine per cent nitrogen and seven to eight phosphoric acid, is valued at about \$40 per ton.

**Blood, Flesh,  
and Fish.**

Horn and hoof shavings and waste are exceedingly rich in nitrogen, but this is in a less soluble or available condition, and I think, rated pretty high even at eight cents per pound.

**Horn, Hoof and  
Wool Waste.**

The material contains from fourteen to fifteen per cent nitrogen, and one or two per cent phosphoric acid. Its fertilizing value is about twenty-five dollars per ton.

Wool waste from woolen mills varies greatly in its percentage of nitrogen, some samples having as high as fifteen or sixteen, while others have only six or seven per cent.

Another valuable source of nitrogen is swamp muck, and while available to an unlimited extent on many farms it is seldom appreciated as fully as it deserves. Its nitrogen is not immediately available, but can be made so by composting, and will then be worth as much as that contained in stable manure. This subject will be more fully treated in Nineteenth Chapter. It is of sufficient importance to be urged upon the farmers' attention persistently and forcibly.

Clover and other leguminosæ as means of gathering nitrogen from the atmosphere have already been mentioned.

## SEVENTEENTH CHAPTER.

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### OUR SOURCES OF PHOSPHORIC ACID.

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**T**HE CHIEF sources of phosphoric are four in number; namely: (1) bones of animals; (2) phosphate rocks, which are the fossil remains of pre-historic marine animals; (3) phosphatic guanos; (4) the mineral apatite. Of these, fresh animal bones rank first in people's esteem, although there can be no doubt that phosphoric acid in a soluble condition has exactly the same value whether derived from fresh bones or any other source. Sometimes the agricultural chemist concedes to the fresh bone phosphate more than is just; and practical results must always be the first criterion.

The bones used for the manufacture of fertilizers come chiefly from slaughter-houses and butcher-shops, or are picked up here and there. Fresh bone has nearly one-half of its weight of organic matter—that is, gelatine, water, etc.—and one-half of its weight phosphate of lime. Nearly one-half of the weight of the latter is the phos-

**Bones.**

phoric acid we are after, and this therefore makes out twenty or more per cent of the fresh bone.

Now, bones are treated in a variety of ways to fit them for fertilizer. Often they are steamed, the gelatinous matter extracted for glue, the remainder dried and ground. This process, of course, deprives it of nitrogen, and leaves little besides the mineral elements in it. Another way, and a good one, is to crush and grind the fresh bones. This gives us the "ground bone," "bone meal," "bone dust" and "bone flour," which contain about twenty per cent of phosphoric acid and two to three of nitrogen.

Most of the phosphoric acid is insoluble; that is, in its fixed combination of phosphate of lime, same as it was in the whole bone. Its fine state of division, especially as it appears in bone flour, exposes it to contact with air, moisture, carbonic acid and other influences in the soil, and offers to it many chances of new chemical alliances, so that we need not wonder that plants always know how to get hold of some of this phosphoric acid almost from the beginning, nor that the effect of this bone application is usually quite lasting; of course, all the slower and more lasting the coarser the bone was ground. Its nitrogen also acts in a similar manner; its effect is slow and lasting. Whenever the soil needs phosphoric acid, and little else, and the crops can be given their own time to use it—as winter grains, fruit trees, etc.—finely ground bone may be used to good advantage. An average quality is worth thirty dollars or more per ton.

In bone meal, etc., we have the phosphoric acid in the form of simple bone phosphate of lime. If wanted in a more immediately available form, we thus find it in dissolved bone, which is bone treated

with sulphuric acid. This treatment, as already explained in the first part of this volume, gives us the double, or bi-phosphate of lime, and if continued by further additions of sulphuric acid, the substance called by fertilizer men "superphosphate." In this we have most of the phosphoric acid in a soluble form, or immediately "available," and just in this form it exists in our high-grade fertilizers. We have no means of counteracting the natural tendency of the free phosphoric acid to "revert" when applied to the soil. But this is not usually a serious matter. The "reverted" phosphoric acid is again subject to a chemical action and decomposition in the soil, and therefore may well be considered available, even if not soluble in distilled water. Under average circumstances the reverting process is but slow, and the crops have a good opportunity to help themselves to the free article. The presence of free lime in the soil, of course, accelerates the process of reversion, and where superphosphate is used, or to be used, lime should not be applied.

We have seen that the sulphuric acid treatment, by which the phosphoric acid is made immediately soluble, also results in the formation of sulphate of lime. Consequently, the more soluble, and therefore more valuable, the phosphoric acid in bone phosphate, the greater is the quantity of sulphate of lime contained in it.

The phosphoric acid in bones can also be made partially available by burning, either in open fire or in closed vessels. By the latter procedure we obtain what is called "bone-black." The result of burning bones is chiefly phosphate of lime, without nitrogen. To make

**Bone Black.**

it immediately soluble, however, it will still have to be treated with sulphuric acid, and we then get the "dissolved bone-black."

Great quantities of bones are always accumulating in the course of a season on every farm—heads and feet of slaughtered animals, bones from the kitchen, etc., all of which are usually delivered to poultry, dogs and cats to pick over, and then allowed to remain lying about on the premises where left by the animals. These bones, as already stated, are valuable fertilizing material, containing, besides three or four per cent of nitrogen, nearly one quarter their own weight in phosphoric acid. Their fertilizing value, therefore, is not far from one and one half cents per pound, and would be still considerably larger if all these plant foods were immediately available. Certainly, they are so valuable that we cannot afford to ignore this source of fertilizer, or allow them to remain scattered all over the premises, an eyesore to owner and visitor in their present condition, when they could be made to serve a good purpose. Bones can also sometimes be bought up in the neighborhood at a fraction of their real value. The great problem, however, is, how can these bones be got in proper shape for feeding our crops?

A paragraph familiar to every careful reader of agricultural papers runs about as follows: "Bury a lot of bones (or a dead animal), and set a grape vine or a fruit tree right on top of them." This is an excellent precept, good in cases where only a few bones are on hand and people do not wish to bother with them otherwise. In due course of time—if it should take ten or twenty years—the tree or grape vine will find all the plant food that is in the buried bones, and will make good use of it.

To get bones into an available form for manuring garden and field crops, there are a variety of ways open to us. The simplest of these is burning. Of course, this process deprives the bones of their organic (nitrogenous) matter, so that in the ash of bones we have nothing left but their mineral constituents, chiefly phosphate of lime, with perhaps a trace of potash; but this plant food is in a condition which fits it for use, more or less immediate, by plants. My own favorite way (burning in the heap of rubbish) has already been fully described in Fourteenth Chapter. Bones burned in a furnace or stove where wood is used for fuel add largely to the value of the wood ashes as a fertilizer, by adding their own phosphoric acid to that already there, and to the rich store of potash.

Another way in which we can make bones available for plant food is by mixing them, after having been broken into small pieces by grinding or pounding, with fresh horse manure, and piling this up to come to a lively fermentation. This treatment softens them. It saves all their elements of plant food, and is a good way for the average farmer.

A third way of making bones available for manure is by exposure to the chemical action of unleached wood ashes. They should be broken up as finely as possible, and put in alternate layers with the ashes in a barrel or hogshead, packed down quite solid, in a similar way as you would set a leach. Then pour on water or still better the rich liquid dipped up from the barnyard until the whole mass is moistened clear down to the bottom. Leave in this condition, occasionally putting on a little more water to keep the mass moist all the time, until the

bones, in the course of three or six months, or a year, have become soft and can easily be broken in small fragments.

The fourth way is that by acid treatment. I do not commend it to the average farmer, when any other way is open. The farmer is not a chemist, and handling such corrosive substances as sulphuric acid is hardly his province. There is always an element of danger in this business, and the inexperienced had better not seek too intimate acquaintance with it. On the other hand, if you are bound to try it, there is no great difficulty connected with learning all that is needed about it. Only use the utmost care, and be sure you know what you are doing. Put on old clothes when working with acids, and keep within easy reach a little baking soda (bi-carboate of soda), unleached wood ashes or some other alkali, and rub some of this on at once should a drop of acid spatter on clothes, boots, or flesh.

For a vessel in which to dissolve the bones, make a large tank, box or vat of sound plank. If lined with lead, all the better. Break up the bones as finely as possible; heap them up in the bottom of the tank, and thoroughly wet them with water. Then gradually, carefully, add the sulphuric acid (oil of vitriol). Some commotion and considerable heat will be the result of the contact of the acid and the bones. The mass is to be shoveled over repeatedly, and more acid added, until fifty pounds of the latter have been used to every one hundred pounds of bones. The acid, or oil of vitriol, can be bought in "carboys" of one hundred and sixty pounds each, costing about \$2.25 or \$2.50. The heap is again shoveled over a few times, and after a while will be reduced to a pasty mass. This must be



dried by the addition of bone flour (if you have it) or with dry muck, dry wood ashes, potash salts, etc.; it is then a complete fertilizer, although, perhaps, not excessively rich in nitrogen.

If we were compelled to depend for our supply of phosphoric acid on the bones of animals of our own period, we would be in a bad fix indeed. But it so happens that vast quantities of fossil bones—the

**Phosphate  
Rock.**

bones of all sorts of animals that inhabited the sea, and swamps, and ponds, etc., probably long before the era of man—are stored up in various parts of the world, especially in North and South Carolina, in Florida and elsewhere. An immense accumulation of the best article of this kind is found in South Carolina, and this contains from forty to sixty per cent of phosphate of lime. It is known under the name “phosphate rock, or South Carolina rock.”

In order to fit it for use, this rock is ground to a fine powder, and is then called ground South Carolina rock, or floats. In this we have about twenty-seven or twenty-eight, sometimes even more, per cent of phosphoric acid, which of course, is wholly insoluble, or very nearly so. The stations rate this form of phosphoric acid at two cents per pound, making the ton worth eleven or twelve dollars.

If applied in this form to some soils, especially to those destitute of carbonaceous matter (humus), and insufficiently supplied with potash, such as thin, sandy soils, this plain phosphate has usually little or no immediate effect. In soils having potash and carbonaceous matter in sufficient quantity, however, the phosphate flour is very slowly dissolved, and thus made available for plant nutrition.

Where we desire immediate action of the phos-

phoric acid, as in quick-maturing crops, a different course must be adopted; and instead of using plain, ground rock, we must apply phosphoric acid in the soluble state. Thus we have it in "dissolved South Carolina rock." This is raw ground rock or floats, treated with sulphuric acid in same manner as described for fresh bone.

Acid phosphate contains about fifteen per cent of phosphoric acid, twelve of this soluble and three insoluble. A ton of the plain, ground rock has about 540 pounds of phosphoric acid (nearly all insoluble); the acid phosphate has only about 300 pounds, of which 240 pounds is soluble. The pound of soluble phosphoric acid will cost us from five and three-fourths to seven and one-half cents, which is somewhat cheaper than in bone phosphate.

We might also buy the raw ground rock, dissolve it by treatment with sulphuric acid in the way mentioned for bones. To do this we moisten 265 pounds of the ground rock with about eighty pounds of water in a tank or vat, then slowly and carefully add the contents of a carboy (160 pounds) of sulphuric acid (oil of vitriol), sixty-six degrees in strength, and stir thoroughly. The result will be about 450 pounds of dissolved rock or acid phosphate, containing about seventy pounds phosphoric acid, mostly soluble, at a cost of \$3.00 or \$4.00.

The latest reports from Florida assure us that the mines there found, and now opened, may also be considered inexhaustible, and perhaps even easier worked than those in other parts of the south. At the same time the Florida phosphates are claimed to be of a higher grade than the other, and to contain not only phosphoric acid, but also the nitrogen which was in the

**Florida  
Rock.**

bones originally. In short, it would seem that the United States are so abundantly supplied with the most important of all plant foods, and for so long a period, that we may be relieved of all anxiety for the future concerning this material. With all these mines in full working order, there is every reason to believe that prices of this plant food will have a downward rather than an upward tendency.

The phosphatic guanos imported from some of the islands in South America, and supposed to be the droppings of sea fowls, with most of the nitrogen washed out by rain, contain from fifteen to forty per cent of phosphoric acid, and in some cases more or less nitrogen and potash. Usually they are treated with sulphuric acid, and thus changed into superphosphate. But with the abundant supply we have in our own country, I fail to see why it should be necessary for us to look to South America or any other country for phosphoric acid. The same is true of apatite, which is a phosphate rock of supposed purely mineral origin, found in Canada. If treated with sulphuric acid, and thus rendered soluble, apatite is probably as useful as any other form of soluble phosphoric acid; but the raw material is usually considered of less value than South Carolina rock.

**Guano and  
Apatite, etc.**

A waste or by-product of the German and English iron industries, known as Thomas', or basic, slag, phosphate meal, etc., has frequently been mentioned in the press, and at recent horticultural meetings, as a cheap source of phosphoric acid. We used to get it from the New York importer at thirteen to fifteen dollars per ton. Now a firm in Pottstown, Pa., is manufacturing and offering it as fertilizer under the name of "odorless

**Basic Slag.**

phosphate," charging us \$22.50 per ton for it. It contains twenty-one to twenty-two per cent of phosphoric acid, claimed to be for the most part immediately available. If this be true, we get our phosphoric acid (at five and a quarter cents per pound) in this article reasonably cheap. It may be worth the trial. The manufacturers also intend to establish large factories in other parts of the country, notably in the north-west, and altogether it seems that we have here a source of phosphoric acid which will become important, especially for many sections, which, remote from the sea-shores, have heretofore been practically excluded from the benefits of phosphatic manures on account of the heavy tariff levied upon commerce by transportation companies.

Tankage consists chiefly of offal from slaughter-houses, and is a mixture of partly cooked particles of meat and flakes of bone deposited in tanks, in which the refuse from the butcher is treated to separate the grease. It contains fair percentages of both nitrogen and phosphoric acid, the proportion of each generally varying inversely with the quantity of the other.

**Tankage.**  
**Fish Scrap.**

Fish scrap is obtained by drying and pulverizing the residue left from the extraction of oil from fish, and contains, in addition to nitrogen, a fair proportion of phosphoric acid.

## EIGHTEENTH CHAPTER.

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### OUR SOURCES OF POTASH.

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**A**MONG the substances that we might employ for the purpose of providing our lands and crops with potash are, first of all, the alkaline salts imported from Germany, chiefly muriate (or chloride) of potash, sulphate of potash, and kainit. There is only one mine now known where these manurial salts are obtained, but the supply is said to be inexhaustible. The story of its discovery is quite interesting. It is more than thirty years ago, when I stood on the spot, and saw the piles of what was then considered a poor quality of "cattle salt," and rather a "nuisance;" for the government of the little principality of Anhalt-Bernburg was then in search of the pure rock salt, layers of which were supposed to extend over the line to "Leopoldshall," from the great deposits at Stassfurt on the Prussian side. The impure article, however, continued to come, and no pure salt appeared in sight. A

chemist at last discovered the true nature of the stuff brought up from the bowels of the earth, and then it was found what value there was in the heretofore despised "cattle salt." Factories were erected, the mined product sorted, ground, and worked up, and soon the "dung salts" were used to quite an extent, especially also in England. The proceeds from these mines were, for a long time, sufficient to cover all the governmental expenses of the little principality, and the people, for a number of years, had the good fortune to be entirely freed from state taxes. The whole mine system has recently become, by purchase, the property of an English syndicate.

From there we get our supply of potash salts. One of these is the muriate or chloride of potash, which contains from fifty to fifty-five per cent of potash in a readily soluble form. This potash is rated at four and one half cents per pound by the stations, and a ton of the muriate would therefore be worth about forty-five to fifty dollars. It usually sells for about forty dollars, and, hence, we may consider it a cheap source of this indispensable element of plant food. On the other hand, it needs to be said that this form also contains a considerable percentage of the somewhat objectionable element chlorine, and that when applied in excessive doses to some crops, it may do considerable damage.

For tree and small fruits, this form of potash can safely be used in almost unlimited quantities. With the light we now have on the subject, it seems that for general farm and orchard uses, muriate is about the cheapest source of potash.

Sulphate of potash contains from thirty-five to

fifty-three per cent of pure potash, and the latter is rated at five and one half cents per pound, making the ton worth from \$38.50 to \$58.30. A high-grade article containing fully fifty per cent potash usually can be had for about fifty-eight or sixty dollars, and it is a superior and safe form of this element of plant food.

**Sulphate  
of Potash.**

We also have the double sulphates of potash and magnesia, in which the potash is also rated at five and one half cents per pound. An average sample contains about twenty-six per cent potash; hence it is worth about thirty dollars per ton.

Kainit, although decidedly a low-grade article, is nevertheless a most important form of potash in many respects. Its potash, of which there is only

**Kainit.**

twelve or thirteen per cent, appears partly as sulphate, and partly as muriate. Kainit also contains common salt, gypsum, chloride of magnesium, etc. Its potash is rated at four and one half cents per pound, and the value of kainit per ton should consequently be placed somewhere near eleven dollars. At the mines in Leopoldshall it can be bought for about four or five dollars per ton, and the ocean freight is usually very low, so at the seaports we ought to be able to buy it at eight or ten dollars per ton when buying it by the cargo.

This salt has the power to "fix" ammonia in a most remarkable degree. So it not only gives us our money's worth of potash, but at the same time performs the functions of plaster applications, in saving the slippery carbonate of ammonia, or perhaps even drawing it from the air, for the use of our crops.

Prof. C. A. Goessmann, director of the Massachusetts State Agricultural Experiment Station, an

eminent chemist, wrote me concerning kainit as follows:

“Kainit contains common salt, gypsum, chloride of potassium and sulphate of potash, besides chloride of magnesium. Its compound character is apt to supply known as well as unknown wants of the plants raised by its aid. It is a superior absorber of ammonia, as compared with gypsum; it diffuses potash and phosphoric acid, and renders them more accessible to all kinds of plants, rooting at different depths; it increases the water-retaining quality of the soil. Its large percentage of common salt renders its use in some cases objectionable, but for grass lands and forage crops in general, its application deserves high recommendation. For most garden crops, where stems, leaves and roots are to be used, muriate of potash is safer. For fruits (and sugar and starch-containing plants), carbonate and sulphate of potash are safer potash resources.”

Prof. Dabney says: “Lime promotes the action of kainit to a very marked degree; kainit is, by itself, frequently a proper application to swamp lands and new lands, being, also, a powerful digestive agent.”

For orchards, especially Peach trees, it often proves a veritable panacea, and I have seen some of the diseases of the Peach yield to its application as if by magic.

To sum up, I would say that kainit, as a source of potash, is worth just about its cost; but it gives us so many other advantages besides, that it cannot be doubted that we have in it a valuable manure.

On the other hand, we should not forget that kainit only furnishes potash, and not a particle of other plant nutriment directly, and that it helps to



rob the land of these plant foods; so that in some respects its effect is like that of lime. Without simultaneous applications of other manures it may "make the father rich and the children poor."

The most important domestic sources of potash are wood ashes, cotton seed hull ashes, tobacco dust, and tobacco stems. The composition and values of the various ashes have been given in the chapter on domestic manures. Corn-cob ashes are only second to cotton seed hull ashes in amount of potash.

**Ashes and Tobacco Refuse.**

Tobacco dust contains about 9.05 per cent potash, 3.00 per cent nitrogen, and 2.25 per cent phosphoric acid. Its fertilizing value is near twenty dollars per ton. Tobacco stems contain about 6.50 per cent of potash, 0.60 per cent phosphoric acid, and 2.25 per cent nitrogen, and have a fertilizing value of about twelve dollars per ton.

Saltpetre, if pure, is almost one half potash, with fourteen per cent nitrogen. It is probably worth a hundred dollars per ton. Some of the New Jersey marls, (green sand marl) are said to contain as much as seven per cent of potash. This is not in an available form, but good results are sometimes reported from the use of this material.

**Saltpetre and Marl.**

## NINETEENTH CHAPTER.

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### MUCK AND ITS POSSIBILITIES.

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OUR swamps often contain a gold mine of plant foods if we only know how to make the right use of the materials. It is true, there is a great difference in the value of different samples of peaty and mucky soils, some being much richer than others in nitrogen, some containing mineral elements of plant foods, while others do not, and some being well-nigh worthless.

The kind I have now under consideration is an average sample of black muck, as generally found in bogs and swampy meadows, and which consists almost altogether of decayed vegetable matter, so saturated with water, sponge-like, that the liquid element forms more than three fourths of its weight.

Suppose we have a soil which needs the mechanical effect that stable manure gives, about as much as it does the plant food which the latter contains; in other words, soil in such condition as to require the addition of some bulky, porous substance to open it up; to render it pulverizable, to furnish the

decaying matter which serves as a medium through and in which the process of nitrification is carried on, and to add to its capacity for absorbing and holding moisture, etc. In this case, a fair average quality of muck, properly prepared, may give us every advantage of stable manure at a reasonable cost of materials and preparation.

The chief ingredient of plant food which muck or peat contain is nitrogen, and of this an average sample of wet muck has a little more than one third per cent, or about seven pounds per ton. By exposing the muck for some time to the air, and giving about half of the water a chance to evaporate, we can get it reasonably dry, so that a ton of it would contain twelve pounds of nitrogen. If this were readily available, it would make the ton of this partially dried muck worth about two dollars. Some samples when perfectly dry have so much nitrogen that I have seen the value estimated by some of the stations at nine dollars per ton.

The nitrogen in muck is not readily available, but we will have little difficulty in making it so by a little manipulation. I think I have already mentioned one way on a former occasion. This is by making use of the dry or partially dry muck as bedding for stock—horses, cows, pigs, etc.—and as absorbent in poultry-houses, closets, etc. Here it will soak up the liquids and become mixed with the solids. All that is of value in voidings will be held and saved from waste or deterioration. After having served its purpose in the stables, the muck is thrown together in a square heap to ferment, and is occasionally shoveled over. Thus its own original stores of nitrogen are changed by chemical action and gradually rendered available, so that the manure

thus obtained is far more valuable than the leached stuff so often misnamed "stable manure." In a comparative short time it will be in best possible condition for immediate application, unsurpassed as a top-dressing, especially for garden crops.

We may, however, not keep much, or any, stock that will help us to convert raw muck into a first quality of manure, and in such cases we

**Artificial  
Stable  
Manure.**

will be forced to resort to other means.

For instance, we take a ton of muck having twelve pounds of nitrogen, add to it 200 pounds of unleached wood ashes, having eleven pounds of potash and three and one half pounds of phosphoric acid, and finally fifteen pounds of dissolved bone, having two and one half pounds of phosphoric acid. Now we have

	Nitrogen.	Potash.	Phos. acid.
2,000 lbs. muck.....	10 lbs.	trace.	trace.
200 lbs. wood ashes.....	.....	11 lbs.	3½ lbs.
15 lbs. dissolved bone.....	.....	.....	2½ lbs.
Total, 2,215 lbs., containing...	10 lbs.	11 lbs.	6 lbs.

This material is now thoroughly composted in a similar way as in the former case. No nitrogen is added, as was done by the addition of animal voidings, but the chemical action also helps to render the original nitrogen of the muck gradually available. In the course of manipulation, we probably deprive the muck of some of its moisture, and in the end we will have about one ton of compost, containing twelve pounds of nitrogen, six pounds of phosphoric acid, and eleven pounds of potash, hence being the equal in every way to a ton of an

unusually fine quality of stable manure, worth little less than three dollars at the cost of 200 pounds of ashes, and 15 pounds of bone, plus the labor required in getting out the muck and composting the mixture.

My object in the foregoing has been to show that we often have a way of getting the equivalent of good stable manure when the real article is not on hand, and cannot be purchased. Now, suppose that wood ashes were not to be had, either; then we would have to use some form of potash salts—for instance, kainit, of which eighty pounds would give us just about the quantity required, at a cost of about sixty cents. Since kainit has no phosphoric acid, however, we would also have to increase the allowance of dissolved bone, making it twenty-five pounds instead of fifteen pounds. The materials would then cost us :

80 pounds of kainit,	- - - - -	\$0.60
25 " bone,	- - - - -	40
Total,	- - - - -	\$1.00

It is, of course, not necessary to adhere strictly to these proportions. They may be more or less varied or other plant foods substituted. Instead of bone, for instance, we might use any of the plain phosphates, or dead animals, etc. Or we may simply mix a quantity of the common fertilizers, containing phosphoric acid, potash and perhaps a little nitrogen, with the muck, and thus compost it. More bone than given in these formulæ will be found of service in most cases.



## TWENTIETH CHAPTER.

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### FLESH AND FISH COMPOSTS.

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THE OLD method of disposing of the carcasses of dead horses, cattle and other larger domestic animals, by simply hauling them to the nearest woods or swamp, and leaving them there as a prey to foxes, dogs, crows, buzzards, worms and natural decomposition, is yet widely practiced, but neither nice or wise. I think it is misfortune enough for the farmer to lose a serviceable animal; it would be a foolish act of extravagance for him to let the plant food contained in the carcass go to waste. And the amount of this plant food is not inconsiderable. Suppose we have a dead horse weighing about 1200 pound. Nearly three quarter of this weight is water; in the remaining 300 pounds of dry matter we have something like 200 pounds of dry flesh, and 100 pounds of bone. The dry flesh contains fifteen per cent of nitrogen and a small percentage each of phosphoric acid and potash; the bone contains about twenty-five per cent of phosphoric acid, and

four of nitrogen. Thus we find in the 1200 pound carcass, at a rough estimate, the following quantities of plant food, viz.:

34 pounds nitrogen @ 15½ cents, -	-	-	-	\$5.27
25 " phosphoric acid @ 7 cents	-	-	-	1.75
Total value,	-	-	-	<u>\$7.02</u>

The problem before us now is how to make all this plant food available. We might follow the advice so often given, to bury the carcasses of smaller animals, or pieces of larger ones, at the roots of trees and grape vines. This will put the plant foods to very good use; but, after all, it is a very crude and unscientific mode of application. Fertilizer or "rendering" establishments make a convenient market for all carcasses available within a reasonable distance, and afford to the people in that circle a good chance to sell dead animals, or exchange them for fertilizers. Farmers not having this opportunity, or who, if they have it, wish to make still better use of their dead animals, may get them into available shape for manure by composting them with horse manure, or with muck, turf, etc.

The process is simple enough. Cut the carcass or carcasses into reasonably small pieces, place a layer of these upon a deep layer of muck or fresh horse manure, cover with another layer of muck or manure, and continue in alternate layers, making the heap three or four feet high. Cover the whole with a foot or so of dry muck, turf or loam, and leave until the fleshy matter has decomposed enough to allow the heap to be shoveled or forked over. The process of composting may take a year's time, but it will result in a very rich manure. If muck alone is used, without horse dung, potash may be added in the form of unleached wood ashes, or perhaps better,

in that of kainit, at the rate of 100 pounds of kainit to every 500 or 600 pounds of carcass. It is advisable to add a little kainit even to the flesh-manure compost, and the further addition of 100 pounds or so of some simple phosphate, as bone black or floats, may be desirable for the purpose of rendering the proportion of plant foods in the compost more evenly balanced. At any rate this compost will be very rich in nitrogen, far richer than the very best of ordinary composted stable manure.

Where fish and fish waste is readily procurable at almost nominal rates, as in many places along the sea shores, a cheaper source of nitrogen and phosphoric acid need not be looked for. The material may be composted in somewhat the same manner as described for carcasses; but the compost will be comparatively richer in phosphoric acid. Some kainit, say 100 pounds to each 400 pounds of fish, will make a good addition. I would advise the very liberal use of muck, both in the bottom of the compost heap and as a covering for it. The finest piece of tomatoes I have ever seen was grown on land heavily manured with such fish compost.

**Fish  
Compost.**



## TWENTY-FIRST CHAPTER.

### TABLE OF ANALYSES AND VALUATIONS.

**A**S A sort of ready reference I give the following table, showing composition and valuation of the more important substances purchasable for manurial purposes. The analyses, for the most part, represent an average of a number of samples, and the valuation is compounded on the basis of this year's schedule of prices as adopted by our experiment station. Delivered on the farm, these materials have a correspondingly larger value:—

No.	SUBSTANCE.	Nitro- gen.  Per ct.	Phosphoric Acid.			Pot- ash.  Per ct	Ferti- lizing Value per ton.  \$	No.
			Avail- able.  Per ct	Insol- uble.  Per ct	Total.  Per ct			
1	Apatite (mineral phosph'te)	.....	.....	35.00	35.00	.....	14.00	1
2	Blood, dried ..	9.50	.....	.....	1.90	.....	32.11	2
3	Bone Black dissolved .....	.....	16.65	0.35	17.00	.....	28.04	3
4	Bone charcoal.....	.....	5.00	20.00	25.00	.....	16.00	4
5	Bones ground fine .....	3.90	.....	.....	22.40	.....	43.06	5
6	Castor Pomace.....	5.35	.....	.....	1.95	1.05	19.44	6
7	Coal dust .....	1.85	.....	.....	0.60	trace	.....	7
8	Cotton seed meal. ....	6.10	.....	.....	1.45	0.90	20.54	8
9	Cotton seed hull ashes.....	.....	.....	.....	8.40	22.10	34.39	9
10	Cow manure (varies)....	0.50	.....	.....	0.25	0.45	2.25	10
11	Fish dry ground.....	6.80	4.00	4.10	8.10	.....	33.22	11
12	Guano phosphatic (varies).....	.....	.....	.....	26.75	.....	32.10	12
13	Guano Peruvian .....	5.10	.....	.....	18.45	3.45	41.40	13

No.	SUBSTANCE.	Nitro- gen.	Phosphoric Acid.			Pot- ash.	Ferti- liz'g Value per ton. \$	No.
			Av'ail- able.	Insol- uble.	Total.			
			Per ct.	Per ct.	Per ct.			
14	Hen manure, from high- fed fowls. . . . . }	1.60	.....	.....	1.50	0.80	7.40	14
15	Hog manure (varies). . . . .	0.60	.....	.....	0.40	0.30	2.58	15
16	Horn and hoof waste. . . . .	14.45	.....	.....	2.30	.....	21.61	16
17	Horse manure (varies). . . . .	0.60	.....	.....	0.30	0.50	2.66	17
18	Kainit . . . . .	.....	.....	.....	.....	13.00	11.70	18
19	Leaves, dry forest. . . . .	0.65	.....	.....	0.20	0.40	2.50	19
20	Linsced meal . . . . .	5.25	.....	.....	1.95	1.40	19.49	20
21	Lobster shells, ground. . . . .	6.20	.....	.....	2.30	0.20	21.56	21
22	Muck, wet. . . . .	0.35	.....	.....	trace	trace	1.05	22
23	Muriate of potash. . . . .	.....	.....	.....	.....	51.50	46.35	23
24	Nitrate of soda . . . . .	16.00	.....	.....	.....	.....	46.40	24
25	Odorless phosphate. . . . .	.....	.....	.....	21.00	.....	16.80*	25
26	Saltpetre, pure. . . . .	14.00	.....	.....	.....	47.00	92.30	26
27	Saltpetre waste from gunpowder works. . . . . }	2.45	.....	.....	.....	18.00	26.91	27
28	Sea weed (varies) . . . . .	1.05	.....	.....	0.30	2.00	5.51	28
29	Slag (Thomas or Basic) } See Odorless phosph. }	.....	.....	.....	.....	.....	.....	29
30	Soap works refuse. . . . .	2.25	5.30	10.10	15.40	.....	19.27	30
31	S. C. Rock, ground(floats). . . . .	.....	.....	.....	27.20	.....	10.88	31
32	S. C. Rock, dissolved. . . . .	.....	11.60	3.65	15.25	.....	20.02	32
33	Sulphate of ammonia. . . . .	20.80	.....	.....	.....	.....	75.85	33
34	Sulphate of potash. . . . .	.....	.....	.....	.....	35.95	39.55	34
35	Sulphate of potash (high grade) . . . . . }	.....	.....	.....	.....	52.95	58.35	35
36	Double sulph. of potash and magnesia . . . . . }	.....	.....	.....	.....	26.60	29.15	36
37	Tanbark ashes (spent). . . . .	.....	.....	.....	1.36	2.47	4.35	37
38	Tobacco dust . . . . .	3.00	.....	.....	2.10	9.05	20.57	38
39	Tobacco stems. . . . .	2.25	.....	.....	0.60	6.50	13.97	39
40	Wheat bran . . . . .	2.89	.....	.....	3.04	1.57	13.89	40
41	Wood ashes unleached } hard wood (variable. }	.....	.....	.....	1.50	6.45	9.80	41
42	Wood ashes, leached } hard wood. . . . . }	.....	.....	.....	1.80	1.75	4.09	42
43	Wool Waste†. . . . .	1.20	.....	.....	0.30	3.00	5.04	43

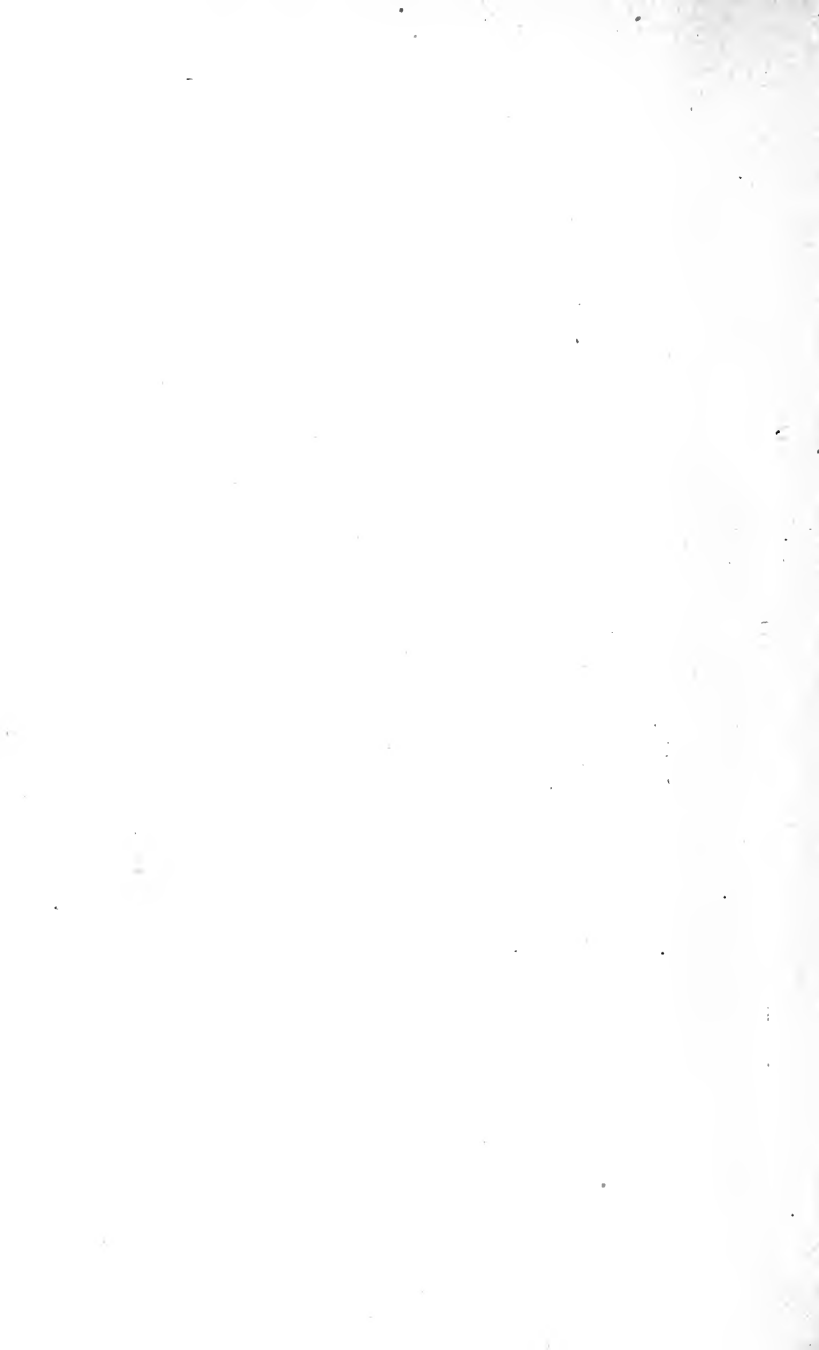
\* The phosphoric acid in this seems to be to some extent immediately available, hence rated at 4 cents.

† Varies greatly, some samples having as high as 17 per cent nitrogen, and a value of \$30.

## PART III.

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# PRINCIPLES OF ECONOMIC APPLICATION.



## TWENTY-SECOND CHAPTER.

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### THE NEEDS OF SOIL AND CROP.

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**A**FTER the perusal of the preceding chapters, the reader will have come to the conclusion that the purchase of fertilizers is nothing more nor less than the purchase of a more or less definite number of pounds of nitrogen, phosphoric acid and potash. The information already given may assist him in buying these articles economically; but this is not sufficient. Economical buying should be followed by judicious, economical use; for the application of manures on the hit-or-miss plan is seldom profitable.

Time and time again I have been asked to name the best manure for this or that crop, and the proper quantity of it to be used per acre. Such questions always place a person in the position of the physician who is called on to prescribe for a sick man without a chance to see him, or to ascertain his true condition by asking him questions, or taking his pulse or temperature. A careful diagnosis should be made before a course of treatment can properly be decided upon. And so it is with the soil. We must try to discover what ails it, before we can apply manures intelligently and economically. A reliable soil diagnosis can not possibly be made from a distance, and without knowing all the par-

ticular circumstances of the case. The farmer himself knows these, and the diagnosis must largely be left to his good judgment.

This is also the case in regard to quantity to be applied. Our old family physician, when asked how much to give of a medicine prepared by him, often used to say: "Use your own judgment." So also the intelligent farmer will be required to use his own judgment in modifying the general rules to

**A Soil  
Diagnosis.**

suit each particular case, bearing in mind also the needs of the particular crop. The most I can do in this connection is to give the reader some hints that will help him in making a correct diagnosis, and to show him how he can let the fertilizer fit his soil and crop.

First of all we should know how much plant food is removed from the soil in a good yield of our ordinary field crops.

Suppose we raise a thirty bushel crop of wheat. We then take off the soil, in the grain alone, about thirty-seven pounds of nitrogen, nine or ten pounds of potash and fourteen pounds of phosphoric acid, and in the straw, perhaps twenty pounds nitrogen, twenty-five pounds of potash and nine pounds phosphoric acid, altogether nearly sixty pounds of nitrogen, thirty-five pounds of potash and twenty-three pounds of phosphoric acid, more or less, and this quantity of plant foods we must return to the soil after each thirty bushel wheat crop is taken off, if we desire to preserve the original fertility of the soil. There may be slight help from

**Plant Foods  
required for  
Grain Crops.**

the atmosphere in furnishing nitrogen as the rains and dews dissolve the floating carbonate of ammonia and perhaps nitric acid, and carry it down to the soil;

but these contributions are small. We must also take into consideration that nitrates may leach through the soil and escape into the drains. The query then is, what fertilizing material does it take to return to the soil the plant food of which we have robbed it by taking off the crop?

Six tons of average farmyard manure would just about replace the amounts of nitrogen (sixty pounds), and phosphoric acid (twenty-three pounds), but would more than make good the loss of potash—in fact give an excess of about twenty-five pounds of it. For other ordinary grain crops the figures approximate those given for wheat.

In stable manure we also replace carbon which the crop has removed, and of which we have taken no account, as it has no quotable value. Uniting with the oxygen of the air, it forms carbonic acid, as already stated, and this not only acts directly as plant food, but also helps in decomposing and rendering soluble the locked-up plant foods in the soil. This carbonaceous matter, as it undergoes slow combustion, keeps the soil open and makes it warmer, exposing it in a greater degree to chemical action, and is especially valuable as an aid in the process of nitrification. The supply of mineral plant foods in the manure is thus supplemented by the slow decomposition of the soil, which often contains immense quantities in its natural state; and the supply of the nitrogenous element is supplemented by additions from the atmosphere.

Thus, if we, in return for an annual crop of thirty bushels of wheat or its equivalent in other cereals, apply six tons of stable manure year after year, we not only return all the phosphoric acid taken off, but also increase the available stores of potash and

perhaps nitrogen. The fertility of the soil is gradually increased, but it will be somewhat one-sided, since the supply of phosphoric acid receives no addition except what the soil itself may furnish in consequence of natural chemical disintegration. Probably there are few farmers that raise cereals thus persistently, and manure thus liberally.

A yearly application of four tons of ordinary mixed stable manure to the acre would replace all the potash and, when we add the amount furnished by the atmosphere, nearly all the nitrogen that the grain crops have taken off. The only important substance not returned in full is phosphoric acid, which is taken off regularly so that the natural supply must be gradually lowered. We will at last come to a stage where its want must be felt. This is the exact condition of thousands of grain farms east, west, and south.

Here we have made *one* soil diagnosis, based merely upon our knowledge of the treatment which a certain soil has received during a period of a number of years. We have come to the conclusion that it lacks phosphoric acid. This we must supply in

**Where Phos-  
phates are  
Needed.**

order to restore the proper balance of the plant foods contained in it. The cheapest way to do this is by the use of a simple phosphate or superphosphate. Among the substances suitable for this purpose, we have bone, bone charcoal, and dissolved bone black, phosphatic guano, basic slag, South Carolina floats and dissolved rock. In some cases especially where the soil is up to our standard of fertility, and time can be allowed for making the phosphoric acid soluble, floats may answer, and will be cheapest. In the majority of cases it will be



safer and preferable to apply phosphoric acid in a more immediately available form, as in dissolved bone black or acid phosphate (dissolved rock). These materials cost fifteen to twenty dollars per ton, and have fifteen or more per cent of phosphoric acid. The application of 200 or 250 pounds, in an occasional rotation with stable manure, while costing but an insignificant sum, will yet serve to set things right, and will answer every purpose of the six ton manure application with its unnecessary excess of nitrogen and potash.

This explains why grain farmers often find the use of phosphatic manure desirable and profitable. We may expect to find just such condition of affairs on farms where enough animals are kept to consume, besides a portion of the grain raised, all the straw and other stover so that the coarser farm productions are returned to the soil in the shape of manure or absorbents. Where milk, and animals (dead or alive) are sold off the place, phosphoric acid is removed all the faster, and the use is all the more in accord with rational crop feeding, and therefore with good farming.

I have to say a word of warning against a very common, and a very great mistake. Farmers who find their crops materially increased by an application of plain phosphatic manures, are only too apt to imagine, that phosphates are specially suited to their soil or crop, and that equally good results will be secured year after year by the same means. Nothing can be further from the truth. If plain phosphates or superphosphates, and nothing more, are put into the soil for a number of years in return for grain and straw, these applications must soon cease to be effective, and the yields will soon fall off.

As no return is made for the large quantities of nitrogen and potash which the crops remove, while phosphoric acid is put into the soil every year in larger quantities even than needed for the grain growth, the land must in the end get very hungry for just the two substances of plant food which phosphates do not provide, and the crops must suffer for the lack of them. To remedy the deficiency in such case, we might apply potash and nitrogen, each in some simple form—potash in German potash salts, green sand marl, ashes, etc; nitrogen in nitrate of soda, sulphate of ammonia, etc., or both plant foods combined in saltpetre waste from gunpowder works, in sea weed, tobacco stems, wool waste, etc.; or better than all this, we might resume the old way of manuring with barnyard manure, until the original balance of soil fertility is restored. If this treatment is again pushed still further, the time soon comes when plain phosphate will once more show good results. All this seems as plain as a simple example in addition and subtraction.

A proper rotation of manures and manurial substances is as important in profitable crop feeding as the proper rotation of the crops themselves. Our chief aim must be the maintenance of a well-balanced soil fertility.

## TWENTY-THIRD CHAPTER.

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### CLOVER AND OTHER PLANTS AS MANURE CROPS.

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**C**LOVER, as hay crop, is one of the chief links in the chain of farm crop rotation; And it is a wonderful crop—somewhat of a paradox. Generally accepted as a “renovator of land,” and a crop which gives to it something like a “resting spell,” it draws more heavily on the supplies in the soil than any other crop; for in two tons of clover hay (supposing such to be a good yield on an acre of good soil, and perhaps a fair equivalent of the thirty bushels of wheat), we take from the one acre about 120 pounds of nitrogen, ninety-three of potash and twenty-seven of phosphoric acid. At the same time the roots and stubs on the same area contain 175 pounds of nitrogen and more than seventy pounds each of potash and phosphoric acid, all of which probably are a kind of reserve store, largely going to supply the materials for the production of after-growth and seed. The whole crop (top and root) has absorbed an aggregate of 300 pounds nitrogen, 165 pounds of potash and 100 pounds of phosphoric acid. Com-

paring these with the corresponding quantities required for the production of grain and potato crops, we find them pretty large indeed; and clover therefore must be called the most exhausting crop that the farmer grows.

When we are told that clover is a "renovator" of the soil, we would naturally feel inclined to ask: What does it *add* to the soil? Its mineral constituents, among them the potash and phosphoric acid, cannot possibly be derived from any other source but the soil. Like other leguminous plants, clover has the power of gathering and assimilating free nitrogen from the atmosphere; but it cannot possibly be enough to make up for the nitrogen taken off in the hay. So we see that the famed "renovator of soils" takes a good deal away, and returns nothing but a portion of the removed nitrogen. Every two tons of clover hay harvested leave the land poorer by ninety-three pounds of potash and twenty-seven pound of phosphoric acid; and if many such crops are taken off, without returning these mineral elements in some form to the soil, it is very plain that the latter must, in the end, lose its fertility.

This explains why clover will not grow on exhausted land, especially on that which lacks potash, for of that substance clover desires a considerable quantity. It further suggests the usefulness of potash on land intended to be seeded to clover, but shy to "take."

While clover thus fails to add mineral elements to the soil, its services as an "accumulator" of available plant foods can hardly be appreciated too highly. From soil and atmosphere it draws its nourishment and stores it in its own tissues. The

one-year-old roots and stubs contain the large quantities of fertilizing substances previously named; and when plowed in, furnish to the next crop a liberal supply of food in a most digestible form. Thus, clover helps along the crop or crops following it; of course, at the expense of the fertility of the soil; and this again makes it plain why farmers like to plant such crops as corn and potatoes on young clover sod.

Besides the three elements of plant food which have a quotable money value, clover, like other plants, collects and stores up carbon, the supply being drawn largely, and if need be wholly, from the air. By growing clover even for hay we can fill

**Clover as Source  
of Carbon**

the soil with carbonaceous matter just as effectively as if we cart coarse stable manure to the fields and plow it in.

It is a comparatively easy matter to supply the soil with the needed minerals. Muriate of potash, kainit, etc., are cheap enough sources of the one; phosphatic rock, phosphate meal, bone black, etc., of the other. These alone, however, if ever so super-abundantly present in the soil, do not make it rich. Such soil may possibly be inactive, without life, for the lack of the needed plant food, nitrogen, and of the mechanical action of carbon. Nitrogen also can be provided, either together with phosphoric acid by application of bones, fish, etc., or alone, by application of sulphate of ammonia, or of nitrates, etc., although this may be at an expense far too large to make it profitable for common farm crops. Thus we can feed a worn-out soil with the substances generally named "chief elements of plant food." In spite of greatest liberality, however, the soil may remain sluggish, and refuse to respond with thrifty

plant growth as promptly as soil fed with stable manure. It yet needs carbon to loosen it, and to protect it somewhat against the ill effect of a dry season. It needs carbon to assist in providing available nitrogen. This carbon cannot be obtained in a simpler and cheaper way than by growing clover or other green crops, and plowing them under.

The farmer who has a big supply of barnyard manure might dispense with clover without serious disadvantages. Where concentrated fertilizers have to be depended upon largely or chiefly as sources of plant foods, clover rotation, or still better manuring with green crops, is absolutely necessary to supplement and complete the application.

This I wish to emphasize. Concentrated fertilizers and green manuring go well together, and make a complete substitute for stable manure. With plenty of chemical fertilizers (potash salts or ashes, acid phosphate, bone meal or phosphate meal, etc., and perhaps nitrate of soda or other forms of nitrogen), and the privilege of using clover, the poorest soil can be made rich in short order, and to produce large yields of any crop—garden or field—for an indefinite period, and the soil be rendered mellow, friable and warm; in short brought into a mechanically perfect condition.

**Clover and  
Concentrated  
Manures.**

The question now is, what plants are best adapted for the purpose of green manuring? Those usually named are the clovers, peas, rye and buckwheat. All of these gather organic matter from the atmosphere, and when plowed under, or left to decay on the surface, add humus to the soil, giving the latter a darker color and increased value. The decaying organic matter is a never-failing source of carbonic

acid, and the amount of this in a soil gives it its immediate productive power.

While the leguminous plants, such as clovers and peas, also have the power to take nitrogen from the free and uncombined stock in the atmosphere—are nitrogen gatherers—rye and buckwheat have no such power, consequently the former should always be selected in preference to the latter.

The use of clover offers the most advantages. The clover roots go down into the subsoil, often to the depth of many feet, and here forage for mineral food supplies unavailable for other crops, or out of their reach, and arrest the nitrogen that in the form of nitrate may be ready to escape into the drains, or into the depth of lower strata. All these foods are brought up nearer to the surface, and held there in readiness for use by other crops after the clover has decayed.

Mechanically, also, clover has advantages not possessed by the other plants named. The lower parts of the roots which are not reached by the plow, and are therefore left to decay where they grow, will leave a multitude of little tubes or channels, perforating the lower stratum like a honey-comb, and allowing the air to pass down freely into the depth of the soil, thereby subjecting it to more rapid changes, hurrying up the decomposition of vegetable matter, and thus adding warmth and promoting healthy growth.

**Advantages of  
Clover and Peas.**

The only objection to the use of clover as manure crop is the comparatively long period needed for its growth. In peas we have a crop that can be produced in short order, and that will make humus and gather nitrogen from the air, but their roots are

surface feeding, and do not bring up plant foods from the subsoil. The black pea or southern cow bean is one of the best plants for the purpose. The cases are few, I think, where it would be advisable to use rye or buckwheat for green manuring. The roots of clover and other leguminous plants have swellings or tubercles, caused and inhabited by bacteria which are the real nitrogen gatherers.

Green vegetable matter is not plant food. To promote its speedy decay, and fit it for the use of other crops, we may plow it under just deep enough to keep it moist, and shallow enough for free access of air. The drainage on soil thus manured should be perfect, and the surface kept well tilled. If lime is absent in the soil, its application will be needed, in order to hasten the decay of the vegetable matter and prevent acid fermentation.

**Plowing in  
Green Crops.**

The next query is, how much of the minerals should be applied along with the green manure in ordinary grain farming, if we desire to maintain our standard of fertility? The object might be accomplished by one of the following applications, viz.:

1. 600 pounds (13 bushels) unleached wood ashes.  
190 pounds of bone meal (or 150 pounds of acid phosphate).
2. 75 pounds muriate of potash (or 300 pounds kainit).  
200 pounds acid phosphate (dissolved bone black) or 140 pounds bone meal.
3. 100 pounds cotton seed hull ashes.  
100 pounds slag meal (or 150 pounds acid phosphate),

or in any other combination that will furnish about the same quantity of potash and phosphoric acid.



## TWENTY-FOURTH CHAPTER.

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### PLANT FOODS NEEDED IN ORDINARY CROP ROTATION.

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**W**HEAT, clover, potatoes, corn, oats—that or a similar one is the five-year crop rotation quite generally practiced by good farmers at the north. With slight variations or modifications it is sometimes kept up on the same place for many years. Of course we desire to know the amount of plant foods that we remove from the soil in these crops. A fairly good yield per acre is approximately as follows: thirty bushels of wheat; two tons of clover hay; 200 bushels of potatoes; fifty bushels of corn; and forty-five bushels of oats. A good farmer, who knows how to make farming pay, rarely raises less, and often more, provided the land had not been run to death before he came in possession of it, or during his early occupancy, while he was yet without experience in feeding his crops. During the five-year period the following plant

foods, approximately, are taken off each acre of ground, viz.:

	Nitrogen, Lbs.	Phosph. Acid, Lbs.	Potash. Lbs.
In 30 bushels of wheat, includ'g straw.	60	23	35
In 2 tons of clover.....	120	27	93
In 200 bushels of potatoes.....	47	24	75
In 50 bushels of corn, includ'g stalks.	67	25	58
In 45 bushels of oats, includ'g straw.	52	19	38
<b>Total.....</b>	<b>346</b>	<b>118</b>	<b>299</b>

A considerable portion of the nitrogen, however, was drawn from the air by the agency of the clover; another, smaller, part probably was washed down from the atmosphere in rains. The exact amount of these outside contributions, however, cannot be determined, and we must be contented with a very rough estimate.

Suppose that the nitrogen from these sources amounts to not much more than fifty pounds, the soil is yet called on, for the satisfaction of the demands of the five crops, to furnish 296 pounds of nitrogen, 118 pounds of phosphoric acid, and 299 pounds of potash. Thirty tons of average good barnyard manure contains about 300 pounds of nitrogen, 120 pounds of phosphoric acid, and 300 pounds of potash—or almost exactly the amount needed for the production of the five crops. Such manure application (an aggregate of thirty tons of stable manure per acre during a period of five years) can not be called excessive. It is practiced by many farmers, and seldom barren of the most satisfactory results. In most cases it will not only maintain, but actually improve the original soil fertility. If

larger crops are grown, of course the applications might be increased correspondingly.

The wisdom of such a rotation must be apparent to every good observer and calculator. The proportion of the three substances of plant food in stable manure is so near like that demanded by the five crops of the rotation, that the balance of the soil fertility can be maintained perfectly by the exclusive use of such domestic manures. Other grain crops might occasionally be substituted for wheat

**Manures for five  
years cropping.**

and oats, and root crops for potatoes, without material change in the general result. The gross returns per acre for the five years will be \$150 or upward, and it seems that we could well afford to apply thirty tons of yard manure to secure that result. But in case this quantity is not at hand, nor to be had by purchase, what then?

In the first place we should use all the yard manure that is available for the purpose; and secondly we should supply the deficiency by other means. The one problem that might bother us, is where to get the large amount of nitrogen? The article is rather costly, and but scantily supplied in the concentrated fertilizers usually available for the farmer. In such emergency we may have recourse to green manuring. A crop of clover or peas will help us to draw on the inexhaustible nitrogen supply of the atmosphere, and to transfer the needed quantity to the soil. The minerals are then easily and cheaply supplied in the form of ashes, or of potash salts, and phosphates, etc, as explained in preceding chapter. On the other hand this makes the addition of one year to the five-year period necessary. In that case clover might again be wedged in between

oats and wheat. It may be sown with the oats and plowed under by August 1st of the following year for the succeeding wheat crop. Then apply a moderate quantity of the mineral plant foods as suggested before, and but little additional manuring with yard manure will be required to maintain our standard of soil fertility. If the clover, however, has failed to catch, on account of poor seed, or neglect to sow it, it will yet be time between spring and wheat sowing to grow and plow in one or two crops of ordinary field peas. Plant thickly enough to have the whole ground covered, and plow under when fully developed. The ashes, phosphates, etc., may be applied before the first pea crop is sown, and will then help to bring out a large growth of vines to be plowed under.

This green manuring is usually the best and cheapest way of furnishing the needed nitrogen, when we have no yard manure, or not enough of it. Still if we have a good muck bed, easily accessible, we may make use of it in the preparation of artificial yard manure, as told in Chapter Nineteenth.

## TWENTY-FIFTH CHAPTER.

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### FEEDING OUR FRUIT AND VEGETABLE CROPS.

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**A**N ALTOGETHER different phase of the manure question from any we have struck in the preceding pages, is met with on farms or lands devoted to fruit growing or vegetable gardening. Complaints about the ineffectiveness of applications of bone meal or other plain phosphates or superphosphates to orchards, vineyards, small fruit patches, and vegetable gardens are nothing at all uncommon. Yet such negative results are just the ones that should have been expected. Why? Because the substances named have little or nothing of value besides phosphoric acid of which fruit and garden crops require only very small quantities.

The following table will show, approximately, what great demands for potash fruit and vegetable crops are making on the soil. This table gives the

number of pounds of the principal plant foods removed in a full crop.

Full Crop per Acre.	Nitrogen, Lbs.	Potash, Lbs.	Phosph. Acid, Lbs.
Apples, 15 tons.....	30	45	3
Pears, 10 tons.....	12	36	10
Plums, 2 tons.....	16	8	2
Grapes, 4 tons.....	13	40	12
Berries, 1½ tons.....		7	2½
Sugar Beets, 20 tons.....	110	72	12
Carrots, 20 tons.....	70	150	24
Mangolds, 20 tons.....	90	160	18
Turnips, 20 tons.....	75	110	25
Onions.....	32	26	23

In all this we have not yet taken any account of the plant foods that have gone into the foliage and the wood of the trees and bushes. Here again potash is just the substance needed in considerable quantity. The leaves dropping in autumn may remain on the ground under the trees and bushes, and thus return their constituents to the soil, or they may be blown away by the autumn gales into fence corners, road sides and ditches, and thus be lost to the soil. The prunings also may be burned up in the orchard or fruit patch giving their mineral constituents back to the soil, or they may be carted off and burned in some back field, where the ashes will do no good to the orchard. Usually there is from these sources at least some loss, chiefly in potash, that together with what the fruit crop has taken off, will have to be made good again by applications of manure.

The table here given may not be more than approximately correct, yet it shows that in fruit crops we remove from the soil an amount of potash, ten, fifteen, and often more times as large as that of phosphoric acid. Many farmers imagine that or-

chards need no manuring. Perhaps a crop of grass with all its large amount of potash is taken off besides. With such great and incessant drain on the potash supply, it will not be long before that supply is getting too short to allow healthy growth of tree, vine or bush, and a full crop of fruit.

Phosphoric acid is used in only small quantities. For these reasons bone meal, phosphates, etc., *alone*, are not what is wanted for a fruit tree manure. Potash is needed more than any other substance, and unleached wood ashes is one of the best forms—if not *the very best*—in which this can be applied. Where good ashes can be bought at ten to fifteen cents a bushel we will not often be able to get a better or cheaper orchard fertilizer.

Prof. C. C. James of Ontario, Canada, recommended at a recent fruitgrowers' meeting the following formula for compounding a cheap and effective orchard fertilizer:

- 40 bushels of unleached ashes.
- 100 pounds of crushed or ground bone,
- 100 pounds of sulphate of ammonia, or nitrate of soda.

This quantity is to be applied at least once in two or three years. It supplies about 120 pounds of potash, twenty-three pounds of phosphoric acid, and twenty pounds of nitrogen.

Nitrogen, if such be needed in greater quantities, can often be obtained in a much cheaper way by the help of crops that are nitrogen gatherers (such as clovers and peas, which should be left on the ground to decay), than by outside applications.

In a majority of cases, perhaps, yard manure is the only form in which plant food is ever given back to the orchard and fruit garden. Twelve tons of it will furnish the 120 pounds of potash needed,

but also two or three times as much phosphoric acid and nitrogen, as required for the crops. It will hardly be good economy, therefore, to use yard manure exclusively, especially if we should have to purchase it at anything like its full value. The cheaper way would be to apply a smaller quantity of yard manure, say one-half the named quantity, or six tons, every second or third year, and add to it the missing sixty pounds of potash in the form of unleached wood ashes, corn cob ashes, cotton seed hull ashes, muriate of potash, sulphate of potash, kainit, etc. Tobacco refuse may also come handy as a source of potash in this emergency. Tobacco dust can be applied directly to the soil. Stems may be either used as mulch, or composted with the yard manure. My ration for the yard manure and potash salts combine would be six tons of the former, and 120 pounds of muriate or sulphate of potash, or 500 pounds of kainit; and would prefer to apply this every second year at least.

We should fully understand, however, that simple phosphates alone are no manure for fruit crops.

Potash, on the other hand, is the chief substance needed, and we can not easily apply it in too large doses for fruits. A sufficiency of potash makes bush and tree fruits firmer, sweeter, better in flavor, and renders the wood more resistant to severe cold.

Vegetable crops usually make still heavier drafts on the potash stores of the soil than fruit crops. In carrots, mangolds or turnips, for instance we remove over 100 pounds of potash per acre if the crop be simply a fair one, and perhaps over 200 pounds, if it be a heavy one. This loss, of course, is usually made up by heavy dressings of yard manure, every

**Potash for  
Fruits.**



ton of which returns to the soil about ten pounds of potash. This calls for applications of at least from fifteen to twenty tons of such manure per acre for every crop, and for larger ones, where very large yields are obtained or aimed at. In any event, yard manure will be found a most excellent fertilizer for these crops, and one of the best means to maintain the balance of soil fertility.

The query now comes up, what to do in case that yard manure is not available? Perhaps the grower, following the advice given by even expert gardeners, has used bone flour, or other phosphates, for some time as a substitute for yard manure. He may have been very liberal in his applications, using a ton or more per acre; yet in all this dressing he has not furnished a single pound of the potash so urgently needed, only a large quantity of phosphoric acid, for which his crop has little use. Consequently the crops must soon suffer for the want of potash, and perhaps of nitrogen.

Having made the correct soil diagnosis again, the proper treatment is easily prescribed. Apply potash and perhaps some quickly available nitrogen. My rations, in such case, would be about as follows, per acre, viz.:

1. 50 to 100 bushels of unleached ashes.  
200 to 400 pounds of nitrate of soda.

The phosphoric acid, contained in the ashes, would do no harm, and in some cases may be needed.

2. 200 to 350 pounds of sulphate or muriate of potash.  
200 to 400 pounds of nitrate of soda.

Cotton seed hull ashes, corn cob ashes, composts of tobacco refuse, with other substances, can also be used to good advantage for the purpose of furnishing the needed potash.

## TWENTY-SIXTH CHAPTER.

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### MANURES FOR FARM AND MARKET GARDENS.

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**I**N THE heavy dressings of compost which the professional market gardeners and truckers give to their lands year after year, and for an indefinite period, immense quantities of the mineral plant foods are put into the soil, most of which are left to accumulate to an extent that few people would imagine.

If the average yearly application amounts to fifty tons per acre (an estimate that can hardly be considered too high, as many gardeners use much more on their highly cropped lands) each acre receives in the 1,000 tons put on during a twenty year period not less than from 8,000 to 10,000 pounds of potash, and from 4,000 to 5,000 pounds of phosphoric acid. Only a small part of these minerals is removed again in the crops, even where large yields are obtained. Twenty onion crops of 600 bushels each, or their equivalent in other succulent market and farm garden crops, consume less than 1,000

**Accumulation  
of Mineral  
Plant Foods.**

pounds each of potash and phosphoric acid; consequently there would be an accumulation, during the time stated, of over 7,000 to 9,000 pounds of potash, and over 3,000 to 4,000 pounds of phosphoric acid to each acre. The bulk of these substances is probably distributed through the surface soil to the depth of, say, eight or ten inches. Consequently this whole surface layer is as rich in mineral plant foods as the very best of ordinary compost. To continue the annual dressings of the same kind of manure would be like carrying coal to Newcastle, or water to the sea.

Such heavy dressings are expensive, no matter whether we produce the manure on the place, or have to purchase it. Every pound of potash in the manure has a commercial value of more than four cents, and every pound of phosphoric acid a value of about six cents. The quantities already put into the soil represent an investment of \$600 or more, and this gives no immediate returns of any kind. Why should we invest more money in bonds that bear no interest, and have a long time to run?

But while the soil itself may have become richer in mineral plant foods than even the barnyard manure itself, no corresponding accumulation of nitrogen has taken place. It can not be said that the soil is destitute of that element. Most of the

Available Nitrogen Needed. crops which the market gardener produces, consume nitrogen faster than mineral plant foods; and besides there is more or less loss of nitrates by leaching. While there may be a considerable supply of nitrogen in the soil, there is at least no accumulation of the *available* form of this element.

The market gardener's success depends in a large

measure on the earliness of his crops, as well as on the succulency of his products. Nitrogen in nitrate form is just the element of plant food of which a generous supply is needed for the production of thrifty, vigorous, succulent growth. When he wants to sow his seed, or set his plants, early in spring, he knows his soil to be already filled with mineral plant foods from previous manuring. The nitrogen alone is not in the available (nitrate) form, and its conversion into nitrate during the cool days of early spring is extremely slow—too slow for the needs of the crop.

The average gardener, in this emergency, again applies his fifty tons of compost, and uselessly adds several hundred pounds each of potash and phosphoric acid to the over-supply in the soil, merely for the purpose of furnishing to his crops a meagre amount of nitrate, which is gradually derived, by the process of natural conversion, from the 500 pounds of unavailable nitrogen in the manure application. In some cases, bone flour, or perhaps complete concentrated manures, are used with similar results and similar waste of mineral plant foods. The few per cent of nitrogen in these fertilizing materials are the only effective agent, while the phosphoric acid in the bone flour, or the potash and phosphoric acid in the complete fertilizer, are added to the stores in the soil, because not needed for the crop in their full quantities. These are—to say the least—round-about ways. The only direct method of supplying the deficiency, and by far the cheapest, is by the use of nitrate of soda, or, in some cases, sulphate of ammonia. Nitrate of soda will answer our purpose admirably. It can usually be bought

**Nitrate of Soda  
in the Garden.**

at about forty-five dollars per ton, and contains fifteen to sixteen per cent of nitrogen in just the form in which it can serve at once for plant food, no matter whether it is in cold or warm weather. In early spring, when the natural conversion of ammonia into nitrate is too slow for the rapid growth of plants, an application of 250 or 300 pounds of nitrate of soda per acre on rich garden soils will have fully as good effects as that of the fifty tons of compost, and in most cases better and quicker ones. If we compare the cost of the two applications, we will find that the use of nitrate of soda means a clear saving of over \$100 per acre. What a waste of ammunition is still going on, in consequence of this "shooting in the dark!"

The question: How shall I mix the nitrate of soda, and how shall I apply it? is quite often addressed to me. When freshly received, the nitrate

**Sowing Nitrate  
of Soda.**

is usually of uniform fineness, resembling ordinary salt, clean and convenient to handle, and may be

sown broadcast over the land as one would sow wheat. If exposed to dampness, however, it will become very lumpy. In such case, empty the nitrate upon the barn floor, break up the lumps with a flail or mallet, and sift; then sow it. A considerable portion usually adheres to the bags. These, when empty, should therefore be soaked in water, and the latter applied to growing crops.

In sowing the dry, sifted nitrate, I have always thrown it promiscuously, and perhaps carelessly, over the crops just starting, such as onions, beets, lettuce, spinach, celery and cabbage plants, etc., and I never had occasion to complain of injury to the foliage. When plants, such as lettuce, cabbage,

etc., have reached some size, however, we should use more care, for if much of the nitrate lodges in the heart of a plant, and slowly dissolves there, it often does considerable injury to the foliage. I always use it alone by itself, and fail to see a single reason in favor of mixing it with any other fertilizer before sowing, although it could be mixed and applied without loss, if the other articles to be mixed with it—perhaps wood ashes, phosphates, etc.—are perfectly dry and the mixture is to be used immediately.

My practice always has been to apply nitrate of soda in small and often repeated rations, perhaps fifty to one hundred pounds per acre, once in eight or ten days, during the earlier stages of growth of the crops. While I am well satisfied with the results of this mode of application, I do not fear that a very great loss would follow a single and large application—say of 300 to 400 pounds—at time of planting.

In localities far from the sea shores, cotton-seed meal may often be employed to best advantage for the purpose of supplying the deficient nitrogen, but the effect can not be expected to be so prompt as that of nitrate of soda. Use 1,200 to 2,000 pounds per acre, and apply broadcast by means of a fertilizer drill before planting.

Sulphate of ammonia, a clean, fine salt-like substance, can be sown by hand, in same way as nitrate of soda, and about in same aggregate quantity, but all in one application just before planting.

## TWENTY-SEVENTH CHAPTER.

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### FERTILIZERS FOR MUCKY SOILS.

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**T**HE reverse of the conditions found in old, heavy-manured market gardens, are met with on soils of a mucky or peaty character, which are often used for the production of vegetable crops, like onions, celery, carrots, mangels and other roots. These soils have all the **Minerals for Muck Lands.** nitrogen that the crops, especially for the later ones usually planted on them, may need. The minerals, however—phosphoric acid and especially potash—are likely to be in very scant supply.

The mechanical texture of such soils may be improved by additions of sand, clay, lime, coal ashes, etc.; but to maintain or increase their productive capacity, applications of phosphoric acid and potash in some form are required, while those of nitrogen would in most cases be superfluous, and consequently wasteful. If we make use of barnyard manure for the purpose of enriching

muck lands, we just about throw away \$1.50 worth of nitrogen, in order to get the use of twenty-five cents' worth of phosphoric acid and fifty-five or sixty cents' worth of potash. The muck needs neither this nitrogen, nor the mechanical action of the bulky organic manure. Hence, we might use the latter to much better advantage for other purposes, and on soils where all its constituents and good qualities are likely to be utilized and appreciated.

In wood ashes, either leached or unleached, we have the most serviceable and often the very cheapest manurial substance for peat and muck soils. If the ashes are leached, their proportion of potash and phosphoric acid is about right for the uses of the crops; if unleached, it may be made right by the addition of superphosphate, Thomas' slag, or other phosphatic manures. Thus, we might mix 2,000 pounds of unleached wood ashes and 400 pounds of phosphatic guano, or Thomas' slag, or bone charcoal, or dissolved bone, or dissolved rock, or perhaps bone meal; we would have a fertilizer analyzing about

**Ashes for  
Muck.**

4 per cent of potash and  $4\frac{1}{2}$  per cent of phosphoric acid. In grain farming, a greater proportion of the phosphatic manures might be preferable; for potatoes and root crops, even a smaller proportion would answer. As a general purpose manure, however, I believe the proportions given are not much out of the way. The question now is, how much of this fertilizer should be applied? This depends on the crop to be grown. For ordinary cereals, a dressing of 500 to 800 pounds would undoubtedly give us comparatively large results. The expense of this application will probably range between five and ten



dollars per acre, according to the price you have to pay for the ashes and phosphates. Leached ashes should be used more liberally, one to two tons per acre not being any too much.

In case ashes are not to be had, or too dear, we must rely on other forms of potash, and I would recommend any of the following formulæ, viz.:

1. 1,000 pounds phosphatic guano (or dissolved bone or rock; or Thomas' slag).  
1,000 pounds Kainit;

Cost per ton about \$20.00. For grains and grasses. Quantity per acre, 300 to 500 pounds, applied in fall, winter or early spring.

2. 1,000 pounds superphosphate (dissolved bone, or its equivalent),  
1,000 pounds sulphate of potash (if high grade, the proportion should be changed to about 1,200 pounds superphosphate and 800 pounds sulphate of potash).

Cost per ton, \$35.00 to \$40.00. For potatoes, root crops and general garden vegetables. Quantity per acre, from 600 to 800 pounds or more. If muriate or kainit are substituted for the sulphate of potash, the application should be made in winter or early in spring.

The chlorides in these potash salts are quite abundant, and should be given a chance to be washed out of the soil, as otherwise they are often injurious, if applied in liberal doses.

3. 1,000 pounds cotton-seed hull ashes,  
1,000 pounds superphosphate in any of its forms.

Cost per ton, \$22.00 to \$28.00. For grains and grasses. Quantity per acre, from 250 to 300 pounds. For potatoes, root crops, and garden vegetables, use more cotton-seed hull ashes and less phosphatic manures.

## TWENTY-EIGHTH CHAPTER.

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### TESTS OF SOIL FERTILITY.

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In many cases, the farmer can not easily get at the record of the crops that have been taken off the fields, nor of the treatment given to them since they were put under cultivation, and consequently he has no data upon which to base his estimate of the probable condition of the soil. In such cases, plants may be utilized as soil analyzers. The great difficulties we meet with in this matter are the variety of soils found on every farm, and the fact that there are seldom two fields alike, and each may have to be examined for itself, making this task of plat testing rather complicated and laborious. On the whole, however, such plat tests are easily made. First, divide the piece for each test in strips of equal uniform width, and then apply the various simple plant foods, one kind to a strip. To the first one, for instance, we may apply a simple superphosphate (dissolved bone-black or South Carolina rock), or perhaps Thomas' slag; to the second, nitrate of soda or sulphate of ammonia; to the third, sulphate of

potash or muriate of potash; to the fourth, wood ashes (phosphoric acid and potash); to the fifth, common saltpeter (nitrogen and potash); to the sixth, bone flour (nitrogen and phosphoric acid); to the seventh, a concentrated, complete manure, and to the eighth, a dressing of yard manure. Of course this arrangement may be varied according to convenience or notion. Or, the substances used in the tests may be restricted to a plain superphosphate, a potash salt, and sulphate of ammonia, or nitrate of soda, alone as well as in connection with one another. The plat is then divided into strips across the first division, and one of them planted to wheat or oats, another to corn, a third to potatoes, a fourth to clover, etc. The harvest will most likely give some indication of what element or elements of plant food are needed.

If, for instance, the complete manures give the best results, we are justified in the assumption that the soil lacks all three chief plant foods; and if, at the same time, the plat fertilized with plain superphosphate gives next best crops, it will show pretty plainly that phosphoric acid is the very first need to be supplied, and it would be a question to our mind whether barnyard manure, with its rather scant supply of that element, would exactly fill the bill, unless supplemented by an additional dressing of plain phosphate or superphosphate. Whatever element or elements of plant food show the most marked results from their application, are the ones of which the soil is most in need, and which can be expected to give good results at least for a time.

I am well aware of the aversion that most farmers have to "fussing" in this manner, and of the difficulty, in many cases, of obtaining a supply of the

substances named in small quantities at a reasonably cheap figure. Even without actual trial of chemical fertilizers, however, we can get an estimate of the needs of the soil by the appearance of the plants. If all our crops, under fair, atmospheric conditions, come up with a rich, dark green color, and grow luxuriantly, we may be sure that the soil is well provided with nitrogen. If they are yellow and sickly from the start, this element, most likely, is in scant supply. Nitrate of soda, in such case, will usually make a great improvement, and this very promptly. Clover is less dependent on a surplus of available nitrogen, and should it refuse to grow thriftily, we may make up our mind that the soil is deficient in potash. The same conclusion would be justified, should potatoes grow plenty of top and little tuber. Still with this crop full success depends on so many other conditions, that we might well call it fickle, and hesitate to base too much confidence upon its behavior. The failure of wheat and corn to produce grain on well developed straw or stalks would lead us to suspect scarcity of phosphoric acid as the chief cause. Observation and good judgment in all these things have to come to our aid in making a correct soil diagnosis.

## TWENTY-NINTH CHAPTER.

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### SOME LEADING PRINCIPLES.

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**A**LTOGETHER it must be considered poor policy to grow any kind of crop without proper feeding. There are cases, however, where the manure supply is scant, and cannot well be replenished. What shall we do with the amount at our disposal?

The same quantity of plant foods needed for the production of thirty bushels of wheat would be sufficient for that of 165 bushels of potatoes, or forty-five bushels of corn, 600 bushels of apples, or other fruit crops in proportion, or several hundred bushels of beets or carrots, or other vegetables in proportion.

Thus a certain amount of plant food in the form of wheat, will give us, say twenty-five dollars; in the form of apples perhaps \$150; in the form of peaches, or strawberries perhaps \$300. This shows plainly how foolish it would be to stint orchard and small fruit patches in order to be able to put the manure on the wheat field. And if we have no manure, or not enough, it will often pay us well to purchase it for use in orchard or strawberry field, when

it would be a matter of grave doubt, whether we could afford to buy it for making wheat of it

Thus in many cases it is with potatoes. We might see our way clear to purchase manure for potato growing, and make it pay, while we could not use it for wheat production without loss. Plant foods seldom have a greater commercial value than in the form of market garden crops. In this form they can be expected to give us the highest returns. Only the florist, the nurseryman, and the seed grower know how to transform plant foods into articles of still greater commercial value. No principle is of greater importance than this that our raw materials of plant food should always be used for the manufacture of those among the crops we grow which will bring us the most money.

Another fundamental principle has already been explained. It is this, that the use of complete fertilizers involves a waste in all cases where the soil already contains an abundance of one or two of the chief elements of plant food, and requires only the supplementary addition of the missing one or two elements to give us all the results we could expect from the complete fertilizer.

Another fundamental principle requires the use of plant foods in most readily available condition for crops that develop and mature in a short period. This applies especially to nitrogen and phosphoric acid. Spinach, radishes, lettuce, and similar crops that come to perfection in a few weeks, need soluble food. Trees and shrubs can in time utilize plant foods that are not immediately available. Winter wheat sometimes produces as good a yield on floats as on superphosphate, etc.

Of not less importance is the observation that a

slight excess of phosphoric acid tends to hasten the maturity of any crop. For this reason it is always prudent to apply some superphosphate to crops requiring a long season, such as tomatoes, melons, corn, etc.

As the fifth and last principle, I will state that barnyard manure, although perhaps just what is wanted otherwise, may be objectionable for certain crops, such as strawberries, onions, etc., on account of the weed seed it contains. If very foul, it should not be used for these crops.



THE END.

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# LARGE CROPS WITH THE MAPES MANURES.

WILMER ATKINSON (Farm Journal) ON THE POTATO CROPS  
(1890) GROWN WITH THE MAPES POTATO MANURE.

We have to record some astonishing results in growing large crops of potatoes with Mapes Potato Manure the past season. Mr. R. A. Chisholm, Del Norte, Colorado, by the aid of Mapes Manure, now so favorably known to *Farm Journal* readers, won the *American Agriculturist* second prize for the season of 1890. One thousand pounds per acre was used, and 847½ bushels per acre were grown. The two largest crops grown with barnyard manure were 434 and 375 bushels. The second largest crop ever grown with fertilizers from one planting on one acre, was produced in Aroostook County, last year, by Philo H. Reed being 745 bushels and 25 lbs, and this also by the aid of Mapes Potato Manure. The great crop (1,031 bushels on one acre), grown in 1889, by Alfred Rose, Penn Yan, N. Y., came from two plantings, each growing side by side. The crop which secured the first *American Agriculturist* prize for 1890, was won by W. J. Sturges, of Wyoming, who produced 947 bushels and 48 lbs. per acre, with irrigation without manure, which shows what virgin soil, rich in potash, will do. The sixth prize in the *American Agriculturist* contest the year before, was won by Mr. Nesbit, of Colorado, whose farm adjoins Mr. Chisholm's, who used a heavy application of stable manure only, his yield being 491 bushels, or 356 bushels less per acre than Chisholm's crop grown with the Mapes Manure.

In growing Mr. Chisholm's crop the land was marked out and drilled three inches deep in furrows, 33½ inches apart with the Aspinwall Potato Planter. The seed was dropped by hand ten inches apart in the furrows on May 16th, making 18,360 hills on the acre. Then 500 lbs. of Mapes Potato Manure was strewn by hand through the furrows, and, of course, directly upon the seed. Now the seed was covered two inches deep with the Aspinwall Potato Planter. Another lot of 500 lbs. of Mapes Potato Manure was sown evenly by hand directly over or along the furrows. The two years' *Agriculturist* contests have clearly demonstrated the superiority of fertilizers or chemical manures over stable manure for potatoes.

(From the *American Agriculturist*, May 18th, 1888.)

## Crops of Corn, 100 Bushels and Over.

Crops of one hundred bushels of shelled corn are rare, but they are not an impossibility. We have seen, on the farm of Mr. E. S. Carman, on Long Island, a crop of one hundred and thirty-four (134) bushels of shelled corn raised on one acre of land. The variety grown was Blount's Prolific, the soil a light sandy loam, the fertilizer used was the Mapes Corn Manure, applied three or four times during the season—altogether not over one-quarter of a ton—and the cultivation consisted of running a cultivator between the rows after every rain, and after the application of the fertilizer. The labor and expense bestowed upon this acre was not more than any intelligent farmer gives to his crop, if he expects a big yield. On the same farm four acres of Chester County Corn yielded eight hundred and fifty-six (856) bushels of corn ears, the best acre 159.37 bushels shelled corn, the poorest 63.74, average, 113.69 (shelled) actual measurement.—*Editors.*

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