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FERTILIZING  
FOR PROFIT

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E. E. MILLER



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# *FERTILIZING FOR PROFIT*

BY

*E. E. MILLER*

*Managing Editor The Progressive Farmer and Gazette*

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## INTRODUCTION.

THE SOUTH spends \$50,000,000 a year for commercial fertilizers, and the amount is steadily increasing—increasing proportionately faster, in fact, than is the average crop production per acre. In other words, Southern farmers spend \$50,000,000 a year for plant foods and then fail to improve their soils. This is true, not because commercial fertilizers are not good to use, but because they are used extravagantly and unwisely.

If all this great sum were spent for the right sort of fertilizers—those needed by the crops on the particular lands where they are grown—and if due attention were paid to the physical condition of the soil—to the humus supply, to drainage, to tilth and texture,—the lands of the South would grow richer and richer with each succeeding year, and instead of thousands of “worn-out” and abandoned fields, gullied, galled, overgrown with briars and bushes, there would be broad acres teeming with crops double and treble those now grown by the average farmer.

It is with the hope that they may point the way to a more judicious and profitable use of fertilizers that the following chapters have been written. While attention is called again and again to the waste of much of the money now spent for fertilizers, and while the fact that commercial fertilizers alone can not maintain soil fertility is repeatedly stressed, there has been no suggestion that commercial fertilizers should not be used. The

writer believes in commercial fertilizers, and that their use will increase; he also believes that it is sheer folly to use them on land that is not well drained or that is hard and dry because it lacks vegetable matter. Nor does he believe that it is any part of wisdom for a farmer to buy fertilizers without some knowledge of what the analysis on the bag means, of just what effect the particular combination he is buying may be expected to have upon plant growth, and without some idea as to what elements of plant food the crop is likely to need most on the land where it is planted.

It is believed that the man who is willing to read these pages carefully, and to think as he reads, will find some help in working out all these problems, and will be able to get a larger return from the fertilizers he uses. No attempt is made to tell any man just what fertilizer he should use or how much, since that is a manifest impossibility; but an effort has been made to make the fundamental facts underlying all fertilization so plain that any one can understand them, and to show the ordinary farmer, busy, and without any special learning along this line, how he can apply them on his own farm so as to make better crops and build up his soil.

Raleigh, N. C.

E. E. MILLER.

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## CHAPTER I.

### WHAT FERTILIZERS ARE AND WHY USED.

**F**ERTILIZERS, as they will be spoken of in these chapters, include any substance containing available plant food, which may be applied to the soil to promote the growth of the crops.

This is one thing which many farmers seem to fail utterly to understand: that fertilizers are food for plants, not medicine for the soil, nor any sort of magic preparation to increase the crops in some mysterious manner. The man who applies nitrate of soda or acid phosphate or stable manure or any sort of "guano" to his crops, does for them just what he does for his live stock when he puts oats into his horses' feed boxes or swill into his pigs' troughs—he feeds them.

Plants get from the air two foods—carbon and oxygen—and from the soil about a dozen others which are necessary to their development. Of these foods, however, only three—nitrogen, phosphoric acid and potash, are at all likely to be lacking in the soil. These three elements, then, are the ones we apply in fertilizers. Sometimes, it is true, lime is supplied, but most soils contain all the lime needed for plant food, and it is generally used for its effect upon the texture of the soil or to sweeten it when sour.

### THE DIFFERENT KINDS OF FERTILIZERS.

With this definition of fertilizers in mind, it may be well next to consider the kinds of fertilizers or manures commonly used:

1. "Green manures" are crops grown to be returned to the soil; and they add humus only, except in the case of the legumes, such as the clovers, cowpeas, soy beans, the vetches, etc. These plants have the power, by the aid of certain bacteria, to take from the air much of the nitrogen needed for their growth and thus add to the nitrogen supply as well as to the stores of humus in the soil. They are discussed more fully in Chapters 14 and 15.

2. Stable manures are valuable both for the humus they add to the soil, and for the plant food they carry. While the amounts of plant food they contain are very small compared with that found in most commercial fertilizers, stable manures, by aiding bacterial activity and chemical action in the soil, also aid in making more available some of the plant food it already contains and are thus beneficial in three ways.

3. "Commercial fertilizers," is the broad term which includes all the substances containing large quantities of plant food that are bought by farmers for their crops. The three elements of plant food they contain are nitrogen, phosphoric acid and potash; and a fertilizer may contain one or all of these. Most fertilizers as sold are mixtures of substances containing these elements in various proportions. Thus the ordinary "8—2—2" fertilizer is likely to be made up of acid phosphate, kainit, cottonseed meal, possibly nitrate of soda, and a "filler" of some kind. The same thing is true of practically all "complete" fertilizers—that is fertilizers containing all three of these essential foods. Commer-

cial fertilizers are generally bought solely for the available plant food they contain.

### THE THREE PLANT FOODS WE BUY.

These three plant foods, which we apply in fertilizers, have each a special function in the growth and development of the plant. While all are necessary to the proper development of the plant, a deficiency in the supply of either is noted by certain characteristic signs. Thus where there is not enough nitrogen, the plants are likely to make a scanty growth of stalk and foliage, to be yellowish in color instead of dark green, and to be generally lacking in vigor and healthiness. Nitrogen, or ammonia, then, directly promotes the growth of stalk and leaves, the vegetative part of the plant.

Phosphoric acid especially promotes the growth and development of the seed, and increases the vigor of the reproductive organs of the plant. When plants make a good growth of stalk and leaf, but produce light and chaffy grain or set few fruits, a lack of phosphoric acid is indicated.

Potash is needed in the formation of starch or cellulose by the plant, and hence plants made up largely of starch cells, like the potato, the turnip and the cabbage, need large quantities of potash. Potash also assists in the formation of the seed, plays an important part in the development of the lint in cotton, adds strength to the straw in grain crops, and color and quality to fruits.

### FOUR FACTS TO REMEMBER.

Thus, while each of these elements has a certain part to play in the building up of the plant structure, it is

essential that all of them be available in sufficient quantities, since one can not take the place of another and all are necessary for the plant's perfect development.

The reader will remember, however, that the plants cannot use any of the food that is in the soil for them, unless it is dissolved in the soil water so that it can be absorbed by the minute root-hairs which are the feeders of the plant. He will remember, too, that many soils do not hold enough moisture because of their lack of humus—"humus," meaning, as it is used here, decaying vegetable matter. Its effects upon crop growth and the need of most soils for it, will be treated more fully in succeeding chapters. Such soils dry out quickly and the plant food they contain is, to a large degree, useless simply because the crops are not able to take it up. On such soils the addition of humus may help the crops more than the application of plant food. Most Southern soils are deficient in humus, and this is why humus-supplying fertilizers—stable and green manures—produce effects entirely out of proportion to the amount of plant food they contain, as compared with commercial fertilizers which contain very little or no humus.

To recapitulate, then: (1) Fertilizers are substances containing plant food which is usually in a readily available form, and (2) are, therefore, used to supplement the plant food that is already in the soil. (3) Since a liberal supply of soil moisture is necessary to enable the plants to utilize the food in the soil, and since a soil deficient in humus, as most Southern soils are, is almost sure to be subject to extremes of drouth and wetness,

the addition of humus to most soils is as important as the addition of plant food; and (4) this is why stable and green manures are worth more—considering the amount of plant food they contain—than commercial fertilizers.

## CHAPTER II.

### WHAT COMMERCIAL FERTILIZERS ARE.

**A**S HAS been explained, commercial fertilizers are used solely for the plant foods—nitrogen, phosphoric acid and potash—they contain, and have not the effect on the physical standard of the soil which is such a marked characteristic of stable and green manures. Some commercial fertilizers, it is true, contain lime which is often of value in correcting acidity and improving soil texture; but this lime is seldom taken into consideration in estimating the value of these fertilizers, and in this chapter will be left out of consideration.

Commercial fertilizers, as we buy them, are usually mixtures of two or more ingredients, each of which may contain one or more elements of plant food. For example, an "8—4" fertilizer—one containing 8 per cent of available phosphoric acid and 4 per cent of potash—is usually made up of acid phosphate and kainit, with sand or loam as a "filler." The common "8—2—2" fertilizer is likely to be made up of acid phosphate, kainit and cottonseed meal; and so on.

The various materials which go into the make-up of commercial fertilizers may, therefore, be divided into three classes according to whether they supply nitrogen, phosphoric acid or potash. Some of them, it is true, furnish two or even all three of these elements, in which case the percentage of each must be considered.

### SOURCES OF PLANT FOOD.

The most common fertilizing materials which supply nitrogen may be divided into two classes, organic and inorganic—those derived from animal or vegetable life, and those that are minerals. In the first class come cottonseed meal, tankage, dried blood, fish scrap, Peruvian guano, etc. In the second class are nitrate of soda, sulphate of ammonia, and two or three other substances seldom used in the South.

There is much difference in the various forms of the nitrogen in these different substances, in the amount of it that can be used at once, the time of its becoming available, etc.; but these points will be treated more in detail in the next chapter.

Phosphoric acid is derived chiefly from acid phosphate and basic slag. The various bone products are gradually being used less and less, and a pound of available phosphoric acid in them usually costs more than in acid phosphate. There is also some phosphoric acid in such organic fertilizers as cottonseed meal, Peruvian guano and fish scrap.

Potash is derived chiefly from the various forms of potash salts taken from the German potash mines—kainit, muriate, sulphate, sylvinit, "manure salts," etc. Of course, some potash is found in practically all fertilizers of vegetable origin,—cottonseed meal, for example, containing about  $1\frac{1}{2}$  per cent. Ashes and tobacco refuse are also potash-supplying materials. A special chapter will be devoted to the consideration of potash and the various forms in which it may be obtained.

### HOW FERTILIZERS ARE MADE UP.

These, then, are things to be remembered about commercial fertilizers: They are valuable solely as sources of the different plant foods, and their value depends upon the amounts of these foods they contain and their availability for the use of plants; they may be made up of a great many different materials, some of which contain one, some two, and some all three of the plant foods we buy; we may buy one element or one ingredient at a time—nitrate of soda, for example, which supplies only nitrogen; acid phosphate, which supplies only phosphoric acid, or cottonseed meal, which supplies some of each of the three elements,—or we may buy them in a mixture, as is generally done; the standard “brands” of fertilizers usually sold consist of two or more ingredients mixed together, generally with a valueless “filler” of some sort to bring their value down to the low prices which most people seem willing to pay.

### WHAT TO CONSIDER IN BUYING FERTILIZERS.

From these facts it is easy to deduce others: In buying a fertilizer the first thing to consider is the amounts of each of the plant foods it contains and their value; the next thing is the need of the crop, on the special soil where it is to be grown, for these foods. A pound of potash, for example, costs now about 6 cents, on the average; a pound of phosphoric acid, about  $5\frac{1}{2}$  cents, and a pound of nitrogen, about 20 cents. A farmer can easily ascertain from these figures which of two fertilizers is the cheaper source of any of these plant foods.

Again, some crops need much larger quantities of certain elements than do others. An amount of nitrogen that would give an excess for an oat crop might be insufficient for a corn crop on the same land.

Soils also differ widely in their demands for the various elements. The sandy slopes of the Atlantic Coast need large amounts of potash, while on the black lands of the Mississippi Valley it almost never gives profitable returns.

It thus becomes evident that the farmer must know what each plant food does for his crop, the commercial value of each food, the amounts of each that his fertilizers contain, and something of the demands of his crop and his soil for these foods, before he can buy or use fertilizers intelligently and to the greatest profit.

### CHAPTER III.

#### WHAT NITROGEN DOES AND WHERE WE GET IT.

**W**HILE NITROGEN is found in various forms or combinations in the different fertilizers, there is only one form in which it can be used as food by plants—the form which the chemists call nitrate. The nitrogen in ammoniac compounds must be changed, by the action of bacteria, to this nitrate form before it can be used; while that in organic matter—green crops, cottonseed meal, or stable manure—must first be changed to ammonia by one class of bacteria, and then to nitrates by another class.

This explains why the nitrogen in nitrate of soda is so much more quickly used by plants than that in cottonseed meal or in a turned-down green crop. In the first case it is ready to be dissolved by the soil moisture and at once taken up by the root-hairs to feed the plant; in the other it must be acted upon by two sets of bacteria which do this work of making the nitrogen compounds available for use—“ammonifying” and “nitrifying” bacteria they are called. These bacteria work best in a loose soil, where there is a good supply of moisture, considerable warmth and plenty of air. Tillage greatly aids their work, while an excess of water in the soil will almost entirely stop it. In a very wet season crops may turn yellow and cease to grow simply because the soil bacteria can not perform their work and no nitrogen is made available as plant food.

**AVAILABLE AND UNAVAILABLE NITROGEN.**

From this it will be seen that the different nitrogenous fertilizers—those supplying nitrogen—are adapted to special purposes. Nitrate of soda is the most readily available of those commonly used, and should be applied, as a rule, to growing crops where it can be used before it is leached out of the soil by rains. In many cases where it is applied even at planting time, large percentages are lost before the crops can use it. The nitrogen in sulphate of ammonia is not quite so readily available as that in nitrate of soda, but is ready for use sooner than that in fish scrap or tankage or cottonseed meal or stable manure. Peruvian guano is a splendid source of nitrogen for most crops because there may be found in it various forms of nitrogen, some readily available and others which will only gradually become so.

These facts must all be taken into consideration in buying fertilizers for any crop. If the fertilizer is to be applied before the crop is planted, the nitrogen may be supplied by cottonseed meal or stable manure; if at planting time, the ideal would probably be to have some ready for use at once, some that would be so in a little while and some, again, that would only become available as the growth of stalk and leaf neared completion. For example, in using a fertilizer for fall-sown wheat or oats, the nitrogen might largely be supplied by the roots and stubble of a leguminous crop; but there would also be needed a little of some quicker-acting form to supply the needs of the crop during the winter and early spring

when nitrification—that is, the changing of the insoluble nitrogen to the available nitrate form—takes place very slowly. If the crop in the spring is yellow and scrubby, a top dressing of nitrate of soda will be the best thing to start it off to immediate growth. The same fertilizer would be the best for rapid-growing garden or truck crops; while for corn, with its heavy root growth and the rapid nitrification that takes place during the summer, stable manure or a turned-down green crop is probably best of all.

#### AMOUNTS OF NITROGEN IN VARIOUS FERTILIZERS.

As sources of nitrogen, then, nitrate of soda is the most readily available, the most easily lost from the soil, and the best for short-lived, quick-growing crops; sulphate of ammonia is a little less readily available; while vegetable and animal fertilizers furnish nitrogen in the best form for crops whose growth is comparatively slow and whose needs are best met by a supply which gradually becomes available.

The percentages of nitrogen contained in the most commonly used fertilizers are as follows: Dried blood, high grade, 13 to 14 per cent; low grade, 6 to 12 per cent; fish scrap, 7 to 8 per cent; tankage, 4 to 10 per cent; cottonseed meal, 6.2 to 6.8 per cent; sulphate of ammonia, 20 per cent; nitrate of soda, 15.5 per cent. There is a wide variability in the composition of all organic fertilizers and they should always be bought by analysis—that is, the price should be determined by the amounts of plant food they actually contain.

Right here it may be well to say that "ammonia" is a nitrogen compound, of which 82.35 per cent is nitrogen. That is, the percentage of ammonia in a fertilizer may be reduced to its equivalent in nitrogen by multiplying by .8235. Three per cent ammonia means 2.47 per cent of nitrogen. Similarly, to reduce nitrogen to terms of ammonia, it should be divided by .8235. For example, a fertilizer containing 3.5 per cent nitrogen contains  $3.5 \div .8235$ , or 4.22 per cent of ammonia.

#### HOW NITROGEN SHOULD BE OBTAINED.

The buying of nitrogen in commercial fertilizers for most farm crops is not a practice to be recommended, since it is the most expensive and the most easily lost plant food, and since, by the growing of leguminous crops, unlimited quantities may be obtained from the air. For truck and garden crops, on the other hand, the readily available forms in commercial fertilizers should be used in addition to the organic forms.

It has been estimated that a crop of cowpeas making two tons of hay to the acre will have gathered from the atmosphere 130 pounds of nitrogen, worth \$26.00 to the soil, and other leguminous crops may do as well. It is easy to see that it is much better to get nitrogen in this way than by buying it at 20 cents a pound, especially as the legume practically always has a feeding value great enough to make its growing profitable without taking this addition of nitrogen to the soil into consideration.

All crops that make a large or rapid growth of leaves and stalks need liberal supplies of nitrogen, and where

the growth of these is insufficient its need is clearly indicated. An excess of nitrogen, however, will produce too great growth of stalk and leaf at the expense of the fruiting qualities of the plant—for example, potatoes “running to tops,” or cotton “going to weed.”

## CHAPTER IV.

### ABOUT PHOSPHORIC ACID.

**T**HE SPECIAL purposes served by phosphoric acid in the building up of the plant structure have already been mentioned—increased fruitfulness and added weight of grain or seed together with earlier maturity.

The absolute necessity of an abundant supply of this element to promote these processes, and the comparatively small amount that is available in the ordinary soil, have combined to make it the leading ingredient of most commercial fertilizers. Perhaps the fact that it is, pound for pound, the cheapest of the three elements usually bought, also helps to account for this; but there is, in most cases, a sound reason for the comparatively large percentage of phosphoric acid in the ordinary commercial fertilizer.

Many people remembering the large quantities of this element applied to many Southern soils year after year, and considering also that very little indeed is lost from the soil by leaching, conclude that it is a wrong policy to continue to buy phosphoric acid, since, as they reason, most soils should be well supplied with it already.

#### THE LARGE SUPPLIES OF PLANT FOOD IN THE SOIL.

They forget that even on the most heavily fertilized soils all that has been applied would amount to an almost inconceivably small percentage, that most soils contain proportionately much less of this than of the other elements, and that when it is applied to the soil it

may "revert" back to an insoluble form and be unavailable for the use of plants. The top six inches of soil on an acre of ordinary land may contain from  $1\frac{1}{4}$  to  $1\frac{3}{4}$  tons of phosphoric acid—as much as would be applied in 156 tons of acid phosphate, or enough to produce good ordinary crops for more than 500 years. The trouble is simply that a very small part of it is in such form that it can be made use of by the crops. What is applied in fertilizers is supposed to be in such form that it can be used at once, and is applied for this reason.

#### "AVAILABLE" AND "UNAVAILABLE" PHOSPHORIC ACID.

Phosphoric acid, then, is found in two forms: Available, or soluble,—when it can be used by the plants; and insoluble, or unavailable,—when it can not be used.

It must be remembered, however, that all "available" phosphoric acid is not equally available. Some of the various forms which the chemists group under this term are much more readily taken up by the plant than are others; while all of them are likely to undergo changes in the soil—to make other chemical combinations—and thus to pass from a soluble state to one partially or wholly unavailable. On the other hand, tillage, plant growth and bacterial action are all the time changing the insoluble forms of all the plant foods into available forms. This explains why a soil may contain large stores of plant food and at the same time make very small crops, and also why no soil can be entirely exhausted of plant food and made utterly unproductive.

### THE PRINCIPAL PHOSPHATIC FERTILIZERS.

The principal commercial sources of phosphoric acid are raw phosphate rock, acid phosphate, bone meal and basic slag.

Bones contain in their raw state from 18 to 25 per cent of phosphoric acid, which becomes very slowly available. Steamed bone, from which the fat and tissues have been largely removed, contains 22 to 28 per cent in a more readily available form; while bone dissolved with sulphuric acid contains from 15 to 17 per cent, which is practically all available. Bone meal is usually the steamed bone ground, and its immediate availability depends largely on the fineness to which it is ground. In addition to the phosphoric acid, raw bone contains from 2 to 4 per cent of nitrogen; steamed bone,  $1\frac{1}{2}$  to  $2\frac{1}{2}$  per cent, and dissolved bone, from 2 to 3 per cent. All the bone fertilizers are what are called "durable" fertilizers,—that is, they become available a little at a time for many years. For this reason they are especially adapted for use on permanent grass fields and for orchard trees.

Basic slag, or Thomas phosphate, is a by-product from the refining of iron ore for steel making. It contains 18 to 24 per cent of phosphoric acid and about 30 per cent of lime. The phosphoric acid is less available than that in acid phosphate.

Phosphate rock, containing from 24 to 32 per cent of phosphoric acid, is mined in South Carolina, Florida, and

Tennessee, and has lately been found in several Western States. When ground in its natural state it is known as raw rock, or "floats," and all the phosphoric acid in it is regarded as unavailable. When mixed with stable manure or with any considerable quantity of decaying vegetable matter, it will, however, gradually be changed into forms that the plants can use.

Ordinarily this raw rock is treated with about its own weight of sulphuric acid, thus forming acid phosphate, the most common source of phosphoric acid. From 14 to 16 per cent of available phosphoric acid is usually found in acid phosphate and in no other fertilizer, perhaps, is the phosphoric acid so readily soluble in the soil water and thus so quickly used by the plants.

Cottonseed meal contains about  $2\frac{1}{2}$  per cent of phosphoric acid; fish scrap, 3 to 4 per cent; Peruvian guano, 10 to 15 per cent, and tankage, 1 to 2 per cent.

For most crops acid phosphate is probably the cheapest and most effective source of available acid phosphate. On acid soils basic slag, although a little less readily available, may on account of the lime it contains give better results; while on soils very full of vegetable matter, floats may often be used to advantage.

Most Southern soils are deficient in phosphoric acid, and its application in some form is a necessity if these soils are to be improved. Most lands, however, if given better tillage, well drained, and well supplied with humus, would beyond all question, make much better use of what was applied and give far greater returns from equal quantities than at present.

## CHAPTER V.

### POTASH IN COMMERCIAL FERTILIZERS.

**M**OST READY-mixed fertilizers contain potash in quantities varying from 1 per cent to 5 per cent, and there could probably be no better evidence than this offered as to the inadvisability of buying fertilizers just because they are called "corn" or "cotton" or "tobacco" fertilizers. For some crops on most soils, and for practically all crops on some soils, the percentages of potash in most ready-mixed fertilizers are entirely too small, while there are other soils on which it seems to be an absolute waste to supply potash at all. The sandy soils of the Atlantic Coast need liberal supplies for the general crops, corn, cotton, and small grains. On the red clay soils of the Piedmont and mountain sections of the South, potash is needed for special crops—fruit and truck, potatoes, etc.; while on the soils of the Gulf States, even on the sands of southern Mississippi and Alabama, potash does not seem to be needed even for these crops. In other words, the cotton farmer on the coastal plains of North and South Carolina who buys a "2—8—2" fertilizer does not get nearly so much potash as his crops demand, while the cotton farmer in southern Mississippi who buys the "2—8—2" fertilizer wastes practically \$2.40 for every ton of such fertilizer he buys, since experiments have shown that on his soil the addition of potash produces no noticeable effect.

In ordinary soils there are far larger quantities of potash than of either of the other plant foods which we buy in commercial fertilizers, and in most of these soils, by good cultivation, the growing of legumes and the occasional use of lime, a fair supply of this element could be readily made available for most crops. Since very little, if any, potash is ordinarily lost from the soil by leaching or evaporation, it is the part of wisdom for the farmer to be sure that there is an adequate supply in his soil. It is only on soils where experiments have shown that potash does not give results that it is safe to dispense with this element if commercial fertilizers are used at all. The fruit grower, trucker and tobacco raiser especially need to be sure that there is an abundant supply of potash ready for the needs of their crops.

#### DIFFERENT FORMS OF POTASH.

Practically all the potash of commerce comes from the Stassfurt mines in Germany, although it comes to us in several forms and under a variety of names.

Probably the most common form is kainit, a crude salt containing about  $12\frac{1}{2}$  per cent of potash. Kainit also contains in addition to the potash large quantities of sodium chloride, or common salt. This is supposed to be useful in preventing the rust of cotton for which kainit is so often used. On the other hand, kainit is not considered the best form of potash for use on Irish potatoes or tobacco, as it tends to make potatoes of an inferior quality—that is, with a smaller per cent of starch—and injures the quality of the tobacco leaf.

Muriate of potash is a refined form of kainit containing about 50 per cent actual potash, and wherever kainit may be used, the muriate will do equally as well and is usually cheaper, considering the actual amount of potash in both fertilizers, for the simple reason that the same amount of plant food can be obtained at less expense for transportation.

Sulphate of potash is another well-known compound containing 48 to 50 per cent of potash. The actual potash in it, pound for pound, usually costs a little more than that in muriate, but it is regarded as a superior form for potatoes and tobacco and is generally used by tobacco growers in preference to other sources of potash.

Still another form of potash is what is known as sylvinit. It usually contains 16 per cent of actual potash. What is known as manure salts or low-grade sulphate of potash contains about 26 per cent of actual potash. It is sometimes used in ready-mixed fertilizers, but seldom sold separately.

Other common sources of potash are wood ashes and tobacco refuse. Unleached hardwood ashes usually contain from 3 to 8 per cent actual potash. Ashes that have been exposed to the weather seldom contain more than 1 to 3 per cent. Tobacco stems contain from 5 to 8 per cent and from 3 to 5 per cent of phosphoric acid. Tobacco refuse is not only valuable as a fertilizer, but is also often of great service as a preventive of damage by insects. Cottonseed meal contains 1.5 to 2 per cent potash, and cottonseed about 1.2 per cent.

### THE INDISCRIMINATE USE OF POTASH.

In applying potash as a fertilizer it is usually best, as is also the case with phosphatic fertilizers, to apply it several days before the seed are planted. This is especially true of the potash salts containing chlorine—muriate or kainit.

As has already been stated, the use of lime tends to make more available the potash already in the soil and the same purpose is served to a certain degree by acid phosphate. On the other hand, potash when mixed with the soil almost immediately forms new compounds in which it is held until released by bacterial action or tillage, so that the loss from the soil is very small.

There can be no doubt that if Southern farmers would take the pains to learn something of the actual needs of their soils in regard to potash, hundreds of thousands of dollars could be saved every year in Southern fertilizer bills. As was said in the beginning, soils of some sections are very deficient in potash, and here the ordinary fertilizers could have a considerable per cent of potash added to decided advantage. In other sections, where the soils already contain an abundance of this element, it is sheer wastefulness for the farmers to continue buying something which their crops do not demand.

## CHAPTER VI.

### WHY FERTILIZERS PAY BEST ON GOOD SOILS.

**A**LL SOILS are made up of very small particles of stone, mixed with decayed vegetable and animal matter. The fine powder that can be scraped off the exposed surface of a limestone ledge is soil in its formative period. In this softened stone, broken up as it is by rain and heat and cold, the little gray lichens which grow on the rocks find a foothold; as they die and decay larger plants follow, and so on. It is by such processes as these, by the wearing of the rains and streams, by volcanic action and by the effects of plant growth and tillage that our soils have been formed. But this finely ground rock scarcely deserves the name of "soil" until it has vegetable matter mixed with it, and until those minute plants we call bacteria begin to grow in it and help change the plant foods it contains to more available forms and thus make it a better home for the plants we grow to live in.

Soils are spoken of as "clay," "loam," "sand," etc., as the soil particles are fine and closely compacted, or larger and looser. A very sandy soil has the disadvantage of drying out quickly. The soil particles are so large that there is not enough moisture held in the thin film which surrounds each of these particles—the "soil moisture" this is called, as distinguished from the water which in wet weather fills the spaces between the soil grains—to supply the crops with the water and the plant food they need. On the other hand, in a clay soil, the very small

particles may be so closely packed together as to prevent the circulation of air in the soil, which is, as has been explained, also necessary for the growth of plants.

### SOIL TEXTURE AND CROP YIELDS.

Thus it is that a very loose or a very tight soil is less likely to give good crops than one in which the soil particles are small enough to hold a plentiful supply of moisture, and yet not so close together as to prevent the æration of the soil and the full development of the fine root-hairs. What are known as "loam" soils—those made up of clay, silt, and sand in varying proportions—are, therefore, generally regarded as the best and most productive lands.

There are, however, considerable differences in the soils best suited to different plants. A rather tight clay is a better wheat soil than one that is loose and sandy. The Irish potato thrives best on a loose, friable loam, while the sweet potato is at home in very sandy lands. The best soil for apples is not the best for peaches; and the adaptable redtop will thrive on a stiff clay where the more particular timothy will last only a year or so.

It is safe to say, as a general rule, however, that the ideal soil, so far as physical condition is concerned, is one that is deep, friable—that is, easily worked,—not very "light" nor excessively "heavy," and containing liberal quantities of decaying vegetable matter.

### HOW HUMUS HELPS TO MAKE GOOD CROPS.

This decaying vegetable matter is the "humus," about which something has been said, and which is by all odds the greatest need of most Southern soils.

When a crop of cowpeas, for example, or a dressing of stable manure is plowed into a sandy soil, as it decays the small particles fill up the larger spaces between the sandy grains, and as each tiny particle is surrounded by a thin film of soil water, this thus enables the soil to retain much more moisture. The rain that falls neither leaches through nor evaporates from the land so rapidly. The decaying vegetation furnishes food for the bacteria that help to make the unavailable plant food in the soil available for the use of the plants. Plant foods, nitrogen especially, that would before have been washed out of the soil by the rains are held for the use of the crops; the soil particles are brought closer together, as it were, and the whole soil becomes a more suitable place for the plants to grow in.

When the green crop or the stable manure is mixed with a clay soil and decays, it prevents the soil particles from packing so tightly together again, and thus permits of a freer circulation of the soil air and prevents the minute spaces between the soil particles from remaining filled with water.

#### SOILS TOO WET AND TOO DRY.

Many farmers can not understand why in a very wet season or on a water-logged soil the plants will turn yellow and fail to grow the same as in a very dry time. The two troubles, in fact, while slightly different in operation, amount to practically the same thing. On the dry soil the plant is unable to find enough soil moisture to dissolve the plant food which it must have for its de-

velopment and, therefore, it fails to grow. In a very dry time the evaporation of water from the leaves goes on faster than it is taken in by the roots, and the plant withers.

On the wet soil, the minute spaces between the soil particles are filled with water, and there is no circulation of air, no bacterial action, the whole machinery—if the term may be used—is brought to a standstill, the plant food is not made available, and the crop is slowly starved—or it may possibly be more accurate to say, slowly smothered.

This will explain why either the addition of humus to a soil or the drainage of it will make it “drier in a wet time and wetter in a dry time.” More moisture can be held without filling up the capillary spaces, and this moisture runs away or evaporates less readily.

#### **WHY FERTILIZERS OFTEN FAIL TO GIVE RESULTS.**

Every farmer knows that it would be a mere waste to put a great quantity of fertilizer on a “sobby” soil and expect to grow a crop. There is too much water in such soils, and they must be drained before good results can be expected.

Farmers must learn, too, that it is unprofitable to put great quantities of fertilizer on dry, dead soils, deficient in humus, where a part of the plant food may be leached away in wet weather, and where all of it may remain practically useless in a dry time because there is not enough moisture in the soil to dissolve it so that it can be taken up by the plants.

It is essential to the economical use of any kind of fertilizers to keep these facts in regard to soil formation and plant growth in mind, because without them there is danger of forgetting the true purpose of fertilizers—the furnishing of readily available food for the crops, and because, important as it is to learn about fertilizers and how to use them, it is even more important to learn how to take care of the soil so as to give the crops a chance to grow and get the most out of the fertilizers applied.

## CHAPTER VII.

### HOW TO TELL WHAT FERTILIZER YOUR SOIL NEEDS.

**T**HE FARMER who has carefully read the preceding chapters will understand that there are several things to be considered in regard to the fertilization of any crop before he goes to buy fertilizers for it.

He will remember, in the first place, that fertilizers are used to supply food for the plants, and that until it is dissolved in the soil-water no one of the elements of plant food, which we supply in fertilizers can be used by the plant. He will remember that it is only in certain form that any of the plant foods can be absorbed by the soil-moisture and that these foods are changed largely to these soluble forms by the action of the soil bacteria. These bacteria, he will remember, get their food largely from decaying vegetable matter in the soil and thrive best in soils that are loose, well drained, warm, and with a fair supply of moisture.

#### SOIL FERTILITY AND PLANT FOOD.

He will remember that in a very dry season large quantities of plant food may lie in the soil perfectly useless to the crop, because there is not enough moisture in the soil to dissolve them so that they can be taken up by the crop. Conversely, in a very wet soil, the excess of water will prevent the circulation of the air which is so necessary if the soil bacteria are to thrive as they should. In short, he will remember that soil fer-

tility depends as much or even more upon the condition of the soil as affected by the supply of humus and moisture, than upon the actual amount of plant food in the soil.

It will be, of course, equally necessary for him to remember the three plant foods which we buy in fertilizers and their special uses:

(1) Nitrogen, whose special office it is to promote the growth of stalk and leaf and add vigor to the plant.

(2) Phosphoric acid, which is especially important in developing the fruit and seed and in promoting earliness.

(3) Potash, which adds strength to the stalk, color and flavor to the fruit, plumpness to the grain and is of special importance in the process of development of starch and fiber.

Of course, he will remember also that there are large amounts of all these plant foods in the poorest land and that the purpose in buying fertilizers is to supply these foods in a form more readily available than they are to be found in the soil.

With these general principles in mind, he will be ready to begin the study of the special needs of each of his crops on his particular soil. He can form a general idea as to what each plant most needs by the sort of growth it makes on his land and he should be able, if he studies his soil at all carefully, as every good farmer must, to judge with fair accuracy as to its physical condition and its ability to make good use of the fertilizers he may supply.

### SOME INDICATIONS OF SOIL NEEDS.

(1) If his soil is what is commonly called rich, and the plants grow tall, strong, and of rich green color, he may be sure that there is an abundant supply of nitrogen present in his soil.

(2) If the plant makes poor growth, but fruits heavily—that is, if his cotton sets many squares on small stalks or his oats and wheat bear heavy heads on short stems, he may be assured that there is at least a fair supply of phosphoric acid present and that the principal need of his soil is for more nitrogen.

(3) If his crops lack general vigor, if his cotton rusts, his fruit is of poor quality and his corn makes spindly stalks and poorly filled ears, he will have strong reason to suspect, especially if his land is light and sandy, a deficiency in the supply of potash.

Of course, he can not expect the best results from any fertilizer on land that is sour or water-logged or that is dry, hard and cloddy, or that runs together and bakes after a rain.

### WHAT TEN EXPERIMENTAL PLOTS WILL TEACH.

He will understand, too, that on most soils there is very often need of more than one of these plant foods, and that while he can form a general idea from the growth of the crops, he must make careful comparative tests, to acquire accurate information as to which plant food is the most needed and in what quantities.

Various methods have been outlined for making these fertilizer tests. One of the simplest and most accurate

is to divide an acre, or half-acre, into ten equal portions, as follows:

Plot No. 1. Plant without any fertilizer.

Plot No.2. Nitrogen should be applied at the rate, say, of 15 pounds—100 pounds nitrate of soda.

Plot No. 3. Apply 25 pounds potash (50 pounds muriate or 200 pounds kainit).

Plot No. 4. Phosphoric acid at the rate of 25 pounds per acre (about 156 pounds 16 per cent acid phosphate).

Plot No. 5. Here both nitrogen and phosphoric acid will be used.

Plot No. 6. Nitrogen and potash will be used.

Plot No. 7. Both potash and phosphoric acid will be applied.

Plot No. 8. All three of these elements are used.

Plot No. 9. Here, too, use all three elements, but only one-half the quantity as in No. 8.

Plot No. 10. is left without fertilization, as a check.

To make such a test of any value, the soil in all the plots must, of course, be as nearly uniform as possible. Each must be planted and cultivated in the same manner and the product of each weighed or measured. Then, too, the cost of the fertilizers and the amount of increase in the crop must be calculated before any one can form an idea as to which fertilizer will pay best on his soil.

#### **TEST THOROUGHLY WITHOUT JUMPING AT CONCLUSIONS.**

It must be understood that on the same soil different results will be obtained in different seasons and the result of any one season's testing is to be regarded as

merely a guide, and not as an invariable prescription. Of course, larger or smaller quantities of any of these fertilizer materials may be used than here indicated, but those given are large enough to afford a fair test and to be comparable to the fertilization ordinarily given staple crops.

It must be remembered, too, that the fertilization indicated for one crop will not be at all what is needed by other crops. This point has already been mentioned and will be referred to again.

#### IT WILL PAY TO MAKE THESE TESTS.

Of course, it takes some trouble to carry out an experiment like this, but it is time and labor well spent. And when it is remembered that the Southern States spend over \$50,000,000 a year for commercial fertilizers, it is easily realized that anything which will enable these fertilizers to be used with more regard to the special needs of the crops to which they are to be applied is worth while.

Often the farmer who is unwilling to make anything like a close study of the fertilizer needs of his soil is enabled to make a test of the most simple order which will enable him to decide what fertilizers to buy and to use them with much more economy than he could hope to do if he merely guessed at the needs of his crop without any study at all. He can leave a few rows of average land not fertilized, and compare the yields obtained from that with the yields obtained from the fertilized rows alongside them. If he uses two kinds of fertilizers he can fertilize

small plots side by side with these fertilizers and leave one not fertilized, and draw a fair idea as to which of them is the more profitable to use. If he applies a top dressing, or makes a second application to his crops, he can experiment by leaving a few rows and note results, or if he is not in the habit of doing these things, he can make the application and judge pretty well the benefits to be derived from it.

In short, anything that will enable him to obtain more accurate ideas as to the fertilizer needs of his soil is well worth considering and will pay handsomely for the time, labor and money spent in carrying it out. It must be remembered, however, that guess-work is seldom accurate and that one may draw ideas entirely misleading, from comparative tests in which there is not accuracy or where the results are only estimated.

### **THE THREE PROBLEMS IN THE USE OF FERTILIZERS.**

The farmer who wishes to use fertilizers on a business basis and get the most out of them will not be content with such guess-work. He will make a close study of his soil and try to find out just what it needs for each of the crops to be grown on it. Above all, he will realize that no application of plant food can take the place of vegetable matter, which the soil must have to produce the best results. The soil is more important than the fertilizer and unless the soil is in the proper condition, best results can not be obtained even from the fertilizers which are most needed by the crop which is being grown.

The primary problem is that of getting the soil in the

proper condition. Next comes the finding out of what is really needed by the soil, and the third and last great problem is the economical purchase of those elements which the crop requires.

## CHAPTER VIII.

### THE SPECIAL NEEDS OF DIFFERENT CROPS.

**D**IFFERENT crops, as well as different soils, have certain special needs which must be considered in the purchase of fertilizers if the best results are to be obtained. Some plants can utilize plant food in forms which are utterly unavailable to other crops. Certain crops, too, require much larger amounts of certain elements, comparatively speaking, than are required by other crops growing on the same soil with them. The fertilizer needed on a given soil for a corn crop will not be the same as that needed on the same soil by a crop of wheat, or cowpeas, or cotton. All these things the farmer must consider when he goes to buy his fertilizers. It is impossible to give any exact formula which will be best for any crop under all conditions, but there are a few general principles which should be kept in mind.

#### SOME SPECIAL NEEDS OF WHEAT AND CORN.

Corn, for example, needs an abundant supply of all the elements of plant food, requiring during the growing season especially large amounts of nitrogen to enable it to make a strong growth of stalk and leaves, and thus to attain that vitality and vigor of growth which will enable it later in the season to mature a heavy crop of grain, for which considerable quantities of phosphoric acid and potash will be demanded.

Wheat and oats need a liberal supply of nitrogen during the first few weeks of growth. Throughout the win-

ter, growth proceeds more slowly and there is less demand for so much readily available food—in fact, large quantities of soluble nitrogen applied to a wheat or oat crop in the fall would be likely to be wasted, at a considerable expense, by the leaching of the winter rains, especially if the crop had not made a good start before cold weather came on. It is different in the spring when the new growth begins; then there is a demand for readily available nitrogen, and this is why a top dressing of nitrate of soda so often produces such marked results on a field of winter grain. As the crop matures there must be available a sufficient store of phosphoric acid and potash to insure stiffness of straw and well-filled heads. A lack of these elements at this time will mean weak straw and shrunken, immature grain.

#### LEGUMES AND TRUCKING CROPS.

For most of the leguminous crops it is necessary on many soils to supply only phosphoric acid, since they are able to get their supply of nitrogen from the air. They can not do this, however, unless the particular bacteria which thrive on their roots are present in the soil, and in some cases it is advisable to use nitrogenous fertilizer to give the young legumes a start so that they will be able to supply their own nitrogen. This is often true of the alfalfa crop.

Of course, on those soils where potash is lacking it will also be necessary to supply this element in connection with the phosphoric acid.

Quick-growing crops, as are most vegetables, demand

large supplies of readily available food, since in their few weeks or months of life there is not time for much elaboration of the plant food in the soil. This is why the trucker finds it profitable to apply quantities of fertilizer to his potato or onion crop which the general farmer could not afford to put on his cotton or corn. It may be worth while to remark right here, however, that most of these truck crops are grown in soils already fertile and that this is one of the reasons why such large quantities of fertilizer can be profitably applied to them. As a rule, the richer the land the more fertilizer that can be profitably used. This is readily explained when one remembers that the ability of any plant to take up the food in the soil depends upon the supply of soil moisture and the bacterial life of the soil. In a fertile soil these favorable conditions exist and the plant food which may be applied is readily utilized by the growing crop. In a poor soil—one that is dry and deficient in humus, or water-logged and deficient in bacterial life—plant food applied in fertilizer remains, to a large extent, useless to the crop, simply because conditions are not such that the plants can take it up.

#### SOME RULES WORTH REMEMBERING.

A few general rules—subject to many exceptions, as are all general rules—may then be given as guides to profitable fertilization.

(1) Quick-growing crops require large amounts of plant food in available forms, since there is not time during their growth for the supplies of plant food in the soil to be converted into soluble forms. In this connec-

tion it must be remembered, however, that warmth and moisture are the greatest factors in promoting the bacterial activity which changes insoluble plant food to soluble forms and that these factors are stronger in the summer than during the winter. Nitrification, for example, is much more rapid in a well-tilled corn field during the summer months than in the same field in winter, or when it is planted in a crop which receives no cultivation.

(2) Slow-growing crops, which occupy the land for a number of years, can usually utilize to best advantage those forms of plant food which become slowly available through long periods of time. One would supply phosphoric acid to his potatoes, for example, in the most readily available form, acid phosphate, while for his grass or his orchard trees, the slower-acting and less readily available bone meal is often considered preferable.

(3) Crops whose principal value depends upon their growth of leaves and stalks demand liberal supplies of nitrogen. Those largely made up of starchy cells need much potash; while those in which grain or seed is the principal consideration need especially phosphoric acid. One wishing to grow crisp, tender lettuce, for example, would want to fertilize it heavily with nitrogen. If he were raising potatoes, he would be sure that his soil was abundantly supplied with potash. If a grain crop was being grown, he would give first heed to the supply of phosphoric acid. Of course, any crop must have enough of all of the elements and will be always limited

by that element which is less abundant. But the proportionate needs of crops vary widely. A fertilizer, for example, which would have enough potash for a crop of oats might be entirely too low in this element to produce a maximum yield of Irish potatoes.

(4) The better the soil is, as a rule, the larger the quantity of fertilizer which can be profitably applied and the more completely it will be used by the crops. This supposes, always, that the fertilizers will be adapted to the needs of the crop on that particular soil.

The application of these principles to the individual crop must be left to the man who is growing the crop and who is familiar with the conditions of the soil on which it is being grown. To attempt to give an absolute formula for any crop is pure quackery unless one knows exactly what sort of soil it is to be grown upon. Certain formulas, however, have come to be largely accepted as standards, and a few of these may be given:

#### SOME FORMULAS FOR STAPLE CROPS.

For cotton on sandy loams of the Atlantic States fertilizers of the following analyses have been recommended: (1) Phosphoric acid, 7.5 per cent; potash, 2.5 per cent; nitrogen, 2.5 per cent. (2) Phosphoric acid, 8 per cent; potash, 3 per cent; nitrogen, 3 per cent. (3) Phosphoric acid, 9.5 per cent; potash, 3.4 per cent; nitrogen, 3.3 per cent. On the red clay soils of these States it is recommended that the percentage of potash be reduced one-half.

On the same soils a fertilizer for corn containing 9.5 per cent phosphoric acid is supposed to be fairly well

balanced when it contains 3.6 per cent nitrogen and 1 or 2 per cent potash, as it is used on red or sandy soil.

The per cent of nitrogen, however, should, of course be decreased as the land is richer, or increased where smallness of growth indicates more need for it.

The Alabama Experiment Station recommends the following formulas for cotton: On red lime lands, 10 per cent phosphoric acid, 2.3 per cent nitrogen, and .6 per cent potash; on sandy soils, 9.1 per cent phosphoric acid, 2 per cent nitrogen, and 2.3 per cent potash; for the Long-Leaf pine lands, 8.7 per cent phosphoric acid, 1.9 per cent nitrogen, and 2.8 per cent potash.

The standard cotton formula for most of the soils of Mississippi is two parts of acid phosphate to one of cottonseed meal, while for corn equal parts of acid phosphate and cottonseed meal are recommended.

A standard potato fertilizer analyzes 7 per cent phosphoric acid, 4 per cent nitrogen, and 8 per cent potash; but this is suited only to sandy lands. For clayey soils, 10 per cent phosphoric acid, 4 per cent nitrogen, and 6 per cent potash is a better mixture.

All these analyses are, of course, only suggestive, and are given merely to show the great variations in the needs of the same crops on different soils and of different crops on the same soil. It is only when the farmer makes a study not only of the character of his soil, but also of the particular needs of each crop, that he can buy fertilizers intelligently; and the notion that any one brand of fertilizers will give equally good results on all crops is one that can not be too soon gotten rid of.

## CHAPTER IX.

### WHAT THE ANALYSIS MEANS.

**T**HE READER of these chapters will by this time, of course, understand that in buying fertilizers he must be guided solely by the amounts of plant food in them. The quantities of these plant foods are required by law in most States to be indicated on the bag or other package containing the fertilizer. They are given in the form of percentages—that is, a fertilizer will be labeled, for example, “8 per cent available phosphoric acid, 2 per cent nitrogen, and 2 per cent potash.” There may be other figures on the bag, although the general tendency of legislation is now to allow only these three items, which really tell all that is usually told about the composition of the fertilizer.

Sometimes the percentage of unavailable phosphoric acid will be given. This may safely be disregarded as it is of very slight, if any, value to the farmer and is not considered in fixing the price of fertilizers. Sometimes, also, a certain per cent of “bone phosphate of lime” will be given. This item, too, should be disregarded, as it invariably represents the same thing as the phosphoric acid. In other words, “bone phosphate of lime” is merely a trade name for the compound in which the available phosphoric acid is found. A fertilizer containing 8 per cent phosphoric acid will contain 16 per cent of this “bone phosphate of lime,” as it is called, although the use of the word “bone” is without any justi-

fication whatever, and the terms mean one and the same thing. These figures are simply put on the bag to make the purchaser think he is getting more than is really there.

Another term frequently found is "ammonia." Some times the nitrogen in the fertilizer is figured in terms of ammonia, and again one will find figures something like this: "Nitrogen, 2 per cent, equivalent to ammonia, 2.4 per cent." This, again, is mere duplication, since ammonia is merely a compound containing 82.35 per cent of nitrogen. In other words, 1 pound of nitrogen is equivalent to 1.2 pounds of ammonia, and the placing of both terms in the analysis serves merely to confuse the purchaser.

#### THE AMOUNTS OF PLANT FOODS IN A FERTILIZER.

The percentages that are given simply mean so many pounds to each 100 pounds of the fertilizer. That is, in an 8--2--2 fertilizer there will be 8 pounds of phosphoric acid, 2 pounds nitrogen, 2 pounds potash to each 100 pounds of the fertilizer. So in a ton there will be 20 times this amount, or 160 pounds phosphoric acid, 40 pounds nitrogen and 40 pounds potash. Remembering this, it will be easy for the farmer to find out just how many pounds of each of these plant foods he is supplying to an acre of land. If he uses 200 pounds per acre of 8--2--2, he will apply 16 pounds of phosphoric acid, 4 pounds of nitrogen and 4 pounds of potash to each acre of land.

Always in buying fertilizers then, they are to be

bought by analysis—that is, by the actual amounts of plant food they contain. While it is true that the same amounts of plant food in some fertilizers may be worth more than equal quantities in others, it may be laid down as a general rule that there is little difference in the materials used in the making of most of the brands commonly sold, and that when one has no way of knowing what materials have been used in the mixing of a fertilizer, he should be guided by the figures on the bag showing the amounts of each of the plant foods it contains. Trade names and special crop brands do not count; the thing to consider is the actual amount of each of the plant foods contained in a ton or a bag of the mixture.

The way, then, to decide which of two fertilizers is the cheaper is to ascertain what each actually contains, and to figure out the value of the plant food in each, at the same prices. While the cost of the different plant foods varies in different localities, nitrogen is usually figured at 20 cents a pound, potash at 6 cents and phosphoric acid at 5½ cents. The variation in the prices of the two last named elements may be as much as one cent per pound, while the nitrogen often costs 25 cents or more per pound. Indeed, it is seldom that plant foods can be had at these accepted valuations in mixed fertilizers, since there is always the cost of mixing and often freight charges on account of the use of fillers, to be added to the first cost of the materials used in the fertilizers.

## CHAPTER X.

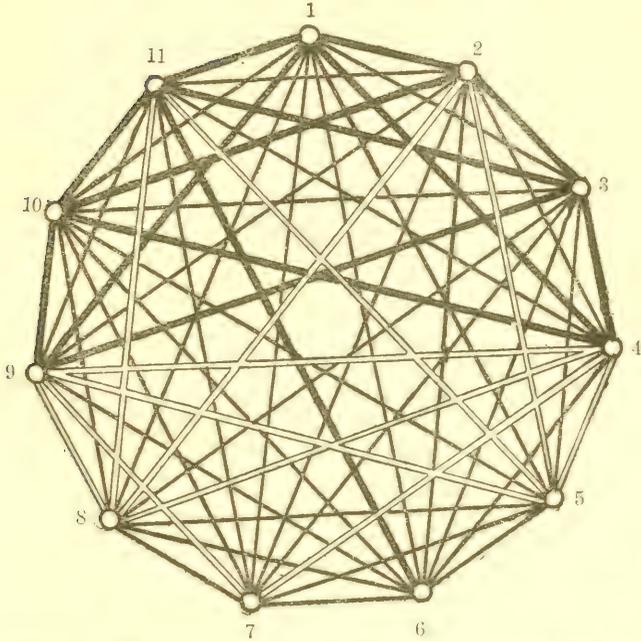
### HOW TO DO HOME MIXING.

**T**HE FARMER who has arrived at the point of purchasing his fertilizers for the plant food they really contain and who wishes to buy only such quantities of each of the plant foods as are profitable and most likely to be demanded, will often find it to his advantage to mix his own fertilizers instead of buying those already mixed by the manufacturer.

If he does this, he will, of course, buy those materials from which the manufacturers themselves make up the standard formulas usually sold. In most cases he will be able in this way to effect a considerable saving in his expenditures for fertilizers, as the work of mixing can usually be done for less on the farm, especially if there is any considerable quantity to be mixed, than the manufacturer charges for doing it.

Another thing to be considered is that the man who mixes his own fertilizers can know just what ingredients supply the various plant foods—something he is unable to do when he buys a ready-mixed fertilizer. The tobacco or potato grower for example, is not able to tell whether the potash he uses comes from muriate or sulphate, though this is often a matter of considerable importance to him.

The only equipment needed for mixing is some sort of scales for the necessary weighing, and a good tight floor on which the materials to be mixed are spread in layers.



#### FERTILIZER MATERIALS THAT SHOULD NOT BE COMBINED.

The above diagram, reproduced by courtesy of the U. S. Department of Agriculture, shows in graphic form the fertilizing materials that may, and those that should not, be mixed together. The heavy lines unite materials which should never be mixed, the double lines those which should be applied immediately after mixing, and the light lines those which may be mixed at any time.

The materials represented by the different figures are as follows: 1. Acid phosphate; 2, Thomas slag; 3, Barnyard manure; 4, Norwegian nitrate; 5, Kainit; 6, Bone meal; 7, Nitrate of soda; 8, Potash salts; 9, Lime nitrogen; 10, Sulphate of ammonia; 11, Lime.

With this key in mind, it is easy to see at a glance what substances should not be mixed together. For example, No. 3, barnyard manure, is connected with 2, Thomas slag; 4, Norwegian nitrate; 9, lime nitrogen, and 11, lime, with the heavy lines. This means that it should not be mixed with any of these substances. With all the others listed it may be safely mixed.

Again, a double line runs from No. 2, Thomas slag, to No. 5, kainit. This means that these substances, if mixed, should be applied to the soil immediately; while with any of the substances to which a light line runs kainit may safely be mixed at any time.

Then a man with a spade begins at one end, cutting down through the successive layers of the different ingredients, and tossing them into a heap at one side. When the whole pile has been gone over in this way the process is repeated, and if the materials are in good condition and the mixing has been carefully done, the fertilizer will, in most cases, be mixed just as well as those that are mixed in the factories.

Of course, if the farmer wishes to be sure of the composition of his fertilizer, he must know—not guess at—the amount of each material he is using, and this means that he must weigh out each ingredient before mixing.

#### HOW TO FIGURE OUT A FERTILIZER FORMULA.

Suppose a farmer has cottonseed meal, acid phosphate and muriate of potash and wishes to make a fertilizer analyzing 8 per cent phosphoric acid, 3 per cent nitrogen and 5 per cent potash. This means he will want 160 pounds of phosphoric acid, 60 pounds of nitrogen and 100 pounds of potash. His cottonseed meal will analyze, if it is a fair sample, 2.5 per cent phosphoric acid, 6.2 per cent nitrogen and 1.5 per cent potash. The acid phosphate, if of high grade, will contain 16 per cent available phosphoric acid. The muriate of potash contains 50 per cent actual potash.

To go more into detail, it is like this: There are 3 pounds of nitrogen in each 100 of the fertilizer. Therefore, in a ton there will be 20 times 3, or 60 pounds. In 100 of cottonseed meal there are 6.2 pounds of nitrogen and, therefore, there will be needed as many hun-

dred pounds of cottonseed meal to supply this nitrogen as 6.2 will go into 60. Dividing, we find this to be 9.7 times, or 970 pounds. The cottonseed meal will also supply 24 pounds of phosphoric acid—970 the number of pounds, multiplied by 2.5, the percentage of phosphoric acid—, and 14.5 pounds, approximately, of potash. This will leave 136 pounds of phosphoric acid to be supplied by acid phosphate, in each 100 pounds of which there are 16 pounds of phosphoric acid; and 85.5 pounds of potash to be supplied by the muriate of potash, in each 100 pounds of which there are 50 pounds of actual potash. Dividing the 136 by the 16—the number of pounds by the percentage—as before, we get 8.5, or 850 pounds of phosphoric acid; and dividing the 85.5 pounds of potash by 50, we get 1.71, or 171 pounds of muriate of potash. This will lack but 9 pounds of being a ton, and it is as near as any fertilizer will approach the exact analysis.

It is seldom, however, that the man who mixes his own fertilizers will mix for any special analysis. He will figure, rather, by the actual amount of plant food he is applying to each acre, and not by the total number of pounds of fertilizer which he puts on.

So, let us suppose that he wishes to supply the equivalent of 300 pounds of 8—2—2 fertilizer to his crop. This will mean that he wishes to supply 24 pounds of phosphoric acid, 6 pounds of nitrogen, and 6 pounds of potash to each acre. If in this case he has the same materials as before—acid phosphate, cottonseed meal and

muriate of potash—he can secure the approximate amounts of each plant food he wishes by mixing 1,125 pounds acid phosphate, 800 pounds cottonseed meal and 75 pounds of muriate of potash. This will give him a fertilizer containing 200 pounds of phosphoric acid, 49.6 pounds of nitrogen, and 49.5 pounds of potash in a ton. That is, the analysis will be, approximately, 10 per cent phosphoric acid,  $2\frac{1}{2}$  per cent nitrogen, and  $2\frac{1}{2}$  per cent potash. To get the equivalent of the 300 pounds of 8—2—2 he will need to use only 240 pounds of this mixture.

#### HOME MIXING REALLY A SIMPLE MATTER.

It will thus be seen that the home mixing of fertilizers is a mere matter of simple mathematical calculation, that when the farmer once knows the composition of the materials he is using in his mixture, it is a simple matter for him to figure out the percentages of plant food in any combination he may make.

In the appendix will be found the analyses of the most commonly used fertilizing materials, and from the figures there given any one can easily calculate the amounts of plant food in any combination he may wish to make, or tell how to combine the different ingredients to make any combination he may wish. There will also be found a list of standard mixtures.

The indirect advantages of home mixing will, in many cases, amount to as much, or more, than will the direct saving in the purchase of the plant foods in the materials to be mixed, over what they would cost if bought

in a ready-mixed fertilizer. When the farmer begins to adapt his fertilizers to his soil and his crop, and not until then, he is on the road to the successful use of commercial fertilizers; and while to successfully mix fertilizers at home he must study not only the needs of each particular crop but also the amounts of the different plant foods and their relative availability in each of the combinations he may propose to make, there is nothing in this work beyond the comprehension of any man of ordinary intelligence who is willing to give a little careful thought and painstaking labor to the solving of one of his greatest problems.

## CHAPTER XI.

### BEST METHODS OF APPLYING FERTILIZERS.

**B**Y FAR the larger part of the fertilizers used in the South is applied in the drill or row with the seed at planting time, and when economy of the operation is considered, it is likely that in most cases it is as good plan as any. Theoretically, the fertilizers applied to the soil should be distributed as uniformly as possible throughout the entire feeding ground of the plants. In practice, however, by putting the fertilizers in the row results equally good may be obtained, especially if they are mixed well with the soil and not brought into contact with the seed in sufficient quantities to reduce their powers of germination. This is especially true when small quantities of fertilizer are used. Where large quantities, 1,000 pounds or more, are used, especially if the soil is well supplied with humus, it is usually advisable to distribute the fertilizers over all the land and mix them with the soil.

#### SOME THINGS TO BE CONSIDERED.

Some fertilizers, however, applied in considerable quantities may injure the seed unless thoroughly mixed with the soil or applied some time before the seed are planted. It is not considered safe to have the seed where they may come into contact with any considerable quantities of most commercial fertilizers. So where they are applied in large amounts it is safer to have them mixed well with the soil.

The question of availability of the different fertilizers is also to be considered in connection with the method of application. Fertilizers that are slow in becoming available should be applied before the seed are planted. Those quickly available, and especially those, like nitrate of soda, which are likely to be lost from the soil, should only be applied when the crop has begun growing. Of course, where only a small quantity of these readily available fertilizers is used, or where they are mixed with other less soluble materials, they may be applied at planting time as a matter of economy, but in such cases it is likely that there is always a slight loss by leaching.

Different crops, too, demand different methods of application. Wheat and oat growers have found it profitable to apply the fertilizer through the drill at seeding time. It might often be better to have it sown on the land some days before the seeding, but it is not likely that in most cases the extra availability of the fertilizer and the lessened risk as regards germination would pay for the extra labor. With corn and cotton it is almost the universal custom to sow the fertilizer with the planter or with a guano sower which puts it in alongside the row. Unless very large quantities—larger, in fact, than are likely to be applied on these crops under ordinary conditions—are used, this is probably the best method, though it is advisable to have a machine that will sow the fertilizer in a wide belt rather than in a single narrow line, and that will also mix it with the

soil so that it does not come directly into contact with the seed.

### ONE OR TWO APPLICATIONS.

Potato and truck growers, who may use as much as 2,000 pounds to the acre, and whose land is generally rich aside from this fertilization, are advised to distribute the fertilizer over the land. Two applications are often profitable with truck and garden crops.

There is no doubt that in many instances a second application to corn, cotton and other staple crops produces an increase in the yield, but the most careful experiments indicate that it is not often that this increase is great enough to pay for the extra labor of application. This rule, however, does not apply when nitrate of soda is used, as its immediate availability suits it for use in this way. In fact, any crop that seems to be suffering from a deficiency of nitrogen may be benefitted by an application of nitrate of soda during the growing period. Its great value as a top dressing for wheat and oats in the spring is well known, and those farmers who depend on commercial fertilizers for the making of their corn crop find that it often pays to use it just as the corn is coming into tassel or beginning to ear.

Grass fields are usually top dressed, that is, the fertilizer is sown over them with a drill or broadcast by hand in the fall or early spring and, preferably, harrowed in. Orchard trees and small fruits should probably have the fertilizer applied broadcast and worked into the soil. The common idea that fertilizer for trees should be applied immediately around the trunk, is

all wrong. The feeding roots of the tree are, in the great majority of cases, out beyond the spread of the branches, and it is here that the plant food should be supplied.

#### FIVE GENERAL RULES.

Special methods of fertilization have been found available for several of the minor trucking and vegetable crops, and the best methods of applying fertilizer in almost every case must be worked out by the man who is best acquainted with conditions, but these general rules may be given:

(1) Where large quantities of fertilizer are applied they should be distributed throughout the whole surface soil; smaller quantities may best be applied in smaller space where the plant roots are sure to find them.

(2) Readily available fertilizers are best supplied when the seed are planted or even after the crop has made considerable growth. Those that become slowly available should be applied, if practicable, before the seed are put into the ground.

(3) It is better in almost all cases to have the fertilizer mixed with the soil so as not to be brought into contact with the seed, but where small amounts are used it is not likely that much harm results from any of the ordinary methods of application.

(4) Two or more applications are profitable, as a rule, only when some quickly available fertilizer is used, or on loose sandy soils in a wet season.

(5) Before any fertilizer is applied the soil should be put into the best possible condition.

## CHAPTER XII.

### A BRIEF REVIEW OF FOREGOING CHAPTERS.

**T**HE PROFITABLE use of commercial fertilizers depends, as has been stated before, largely upon the understanding by the farmer of a few fundamental principles, and his ability to apply his understanding of these principles to his particular conditions. Therefore, it may be well at this point to review briefly, even though it means some repetition, the essential principles of profitable fertilization as laid down in the foregoing chapters. Then, in following chapters, the larger question of soil fertility will be taken up and the use of green and stable manures briefly discussed. We fertilize primarily to get profitable crops, but we must also look beyond the present crop to the permanent effects upon the soil. This chapter and the next will be devoted to this phase of the subject.

In the first place, it must always be remembered that fertilizers are primarily plant foods; that they bear the same relation to the plant that corn and oats do to the horse, or bread and meat and butter do to the farmer himself. In any soil there is enough of all the plant foods to supply the needs of very large crops for a great many years, but most of these foods are in such form that they can not be used by the crops. It is only when these foods are dissolved in enough soil water to enable the plants to draw them up through the minute root-hairs by which they feed, that they can be utilized at

all. The farmer who applies fertilizers to a soil, then, simply puts food for his crops where it can be reached by them. And to be of any value, this food must be in a form in which the plants can utilize it.

### THE THREE PLANT FOODS WE BUY.

The three plant foods usually applied are nitrogen, which goes largely to the development of leaf and stem; phosphoric acid, which is useful chiefly in promoting the development of fruit and grain, and potash, which aids in the production of starch and gives vigor to stem and foliage and perfection to flower and fruit.

The most commonly used fertilizing materials supplying nitrogen are cottonseed meal, nitrate of soda, tank-ake, dried blood, fish scrap, and stable and green manures. Phosphoric acid is chiefly derived from acid phosphate, floats, basic slag, and bone meal. Potash is bought chiefly in the form of muriate, sulphate and kainit, and is also obtained in considerable quantities from wood ashes and tobacco refuse. A fertilizer containing all these elements of plant food is known as a "complete" fertilizer.

### WHAT LIMITS THE CROPS.

It must be remembered always that the growth of any crop is limited by the supply of that plant food which is least abundant, and no surplus of any one element can make up for a deficiency of another. Indeed, the growth of the crop is limited by the lack of moisture in the soil to make available the plant food there present, of-

tener than by any actual lack of the elements which the plants feed on. Other limiting factors of crop growth may be too much moisture in the soil, soil acidity, or poor physical condition which does not permit of proper aeration of the soil and of the necessary development of bacterial life.

It is because they correct these difficulties in the soil that stable and green manures are so much needed on most Southern lands. And it is for the same reason that the same amount of plant food applied in these manures will usually give far better results than an equal amount of more readily available food applied in the form of commercial fertilizers. Indeed, it is not too much to say that in most cases the greatest need of the soil is a larger supply of humus which will give better texture to the soil, increasing its moisture-holding capacity and permitting of freer circulation of the air, and thus enabling the development of the soil bacteria which change the elements of plant food in the soil to available forms and make it possible for the crops to utilize them.

It is always to be remembered that even when commercial fertilizers are applied, the ability of the plant to use them is governed largely by the condition of the soil, and that it is useless to expect the best results from any fertilizer on a soil which is improperly drained, which is dry or hard, or which is insufficiently supplied with decaying vegetable matter. The man who wishes to use fertilizers economically must, therefore, give first attention to the condition of his soil; for until he has it

in proper shape, he must inevitably fail to get the best results from any fertilizer he may apply.

#### ADAPTING THE FERTILIZER TO THE CROP.

The next thing to consider is the lack of his soil in the available plant food needed by the particular crop he wishes to grow. And until he has some intelligent idea of this, and can therefore determine from a business standpoint what plant foods his crops most need, he can not use fertilizers to the greatest profit.

It may be stated as a general rule that practically all Southern soils, except what are known as "rich" bottom lands, are deficient in nitrogen. And with the possible exception of the alluvial lands of the Mississippi Bottoms all will be made more productive by the application of phosphoric acid. On the sandy soils of the Atlantic Coast region, potash is much needed for most crops, while on the clay lands of the Southern hill country and on the soils of the lower Mississippi Valley, it seems to be needed only for special crops, if at all.

The high cost of nitrogen and the fact that it is so readily lost from the soil, makes it impracticable for the farmer to keep up the supply in his land by the purchase of it in commercial forms. Since it costs about 20 cents a pound, and a crop of cotton yielding a half bale to the acre removes at least 18 pounds, it will be seen at once that some other method of keeping up the supply of this element must be adopted if the farmer is to make a profit on the crops he grows. Fortunately, however, by raising leguminous crops he can keep his soil abun-

dantly supplied with nitrogen, so that all he will need to buy will be a readily available form for special crops or for special occasions of crop need. The growing of these legume crops is, indeed, of much more importance in the long run than is any application of commercial fertilizers.

Phosphoric acid must be bought, and in many cases in increasing quantities, if Southern soils are ever to reach that degree of productivity which may rightfully be expected of them. It is probable, however, that by filling the soil with humus it will be possible to get this phosphoric acid from the raw phosphate rock at a cost of less than one-half of what is paid at present for the more available form in the acid phosphate. Until the soil is supplied with this vegetable matter, however, it is not likely that this unavailable form will give paying returns.

Potash should be applied in larger proportions in some sections and in much smaller proportions on other lands of different type. Indeed, it is probable that on many Southern soils it does not pay to apply potash at all for any of the staple crops. This, as well as the amount and percentage of the other plant foods to be applied, is a matter which can be determined only by careful experiments on his soil by the farmer himself. It is chiefly for this reason that the practice of mixing fertilizers at home in such proportions as are needed by the crop to be fertilized is to be advised. And this is why it is so vitally important for Southern farmers to

learn how, not only to judge of the needs of their soil as regards plant foods, but also to determine the amount of each of the plant foods in a fertilizer and to adapt the fertilizer used to their individual needs.

#### WHAT THE FARMER MUST LEARN.

To sum up the whole matter, then, it may be said that the farmer who wishes to use fertilizers economically must consider first the processes of plant growth and nutrition. He must next consider the special part which each of the plant foods answers in the development of the plant. Then, attention must be given to the composition and physical condition of the soil and to the particular demands of the crop which is to be fertilized. After this, and from a knowledge of these things, the adaptation of the fertilizer to the crop must be made.

All this is a matter involving earnest study and some very careful, painstaking work, but it should be far easier for the farmer to devote this study and work to the solution of his fertilizer problems than for him to continue, as so many are doing at present, to spend a large per cent of his income for fertilizers, buying these fertilizers by guess-work and using them in some cases so as only to assist in the depletion of the soil, and thus to make farming less profitable and more uncertain with each succeeding year.

## CHAPTER XIII.

### KEEPING UP SOIL FERTILITY.

**I**T IS EVIDENT that while the productivity of a soil does not depend entirely, or even primarily, upon the amount of plant food it contains, yet any system of farming that reduces the amount of plant food in the soil is bound sooner or later to bring the land down to such a low degree of fertility that its cultivation will not be profitable. Because the plant food in any soil is largely in an insoluble form and so must be made slowly available for the use of the crops, it follows that it is impossible to absolutely exhaust it of plant food. But it is quite possible to reduce the store of available food to such a small quantity that paying crops can not be made, even though there is really enough in the soil to last for hundreds of years. While the farmer, then, will give due consideration to the humus supply and the physical condition of his land, he must also, if he wishes to maintain its fertility, have regard to the total amounts of plant foods it contains. And while there is in the average soil enough of the different elements needed by crops to last for hundreds of years, it is not the part of wisdom to greatly reduce this total supply, especially when it is remembered that under all circumstances, by far the larger part of what is present in the soil will be in such form that it cannot be used by the crop.

For these reasons, the good farmer will try to add to

his soil as much of the three limiting plant foods as his crops remove from it.

### WHAT CROPS TAKE FROM THE SOIL.

Some very interesting figures along this line might be given, and many farmers will doubtless be surprised when they compare the amounts of plant food applied in the fertilizers they commonly use with the quantities that are removed by the crops grown. In the average crop of corn grown in the United States—29.4 bushels to the acre, and estimating 4,000 pounds of stover—there are 73.74 pounds of nitrogen, 23.96 pounds of phosphoric acid, and 63.06 pounds of potash. In the average wheat crop—13.95 bushels, and estimating the straw at 2,300 pounds—there are 33.32 pounds of nitrogen, 10.2 pounds phosphoric acid, and 16.83 pounds of potash. In the average cotton crop—190 pounds of lint and 414 pounds of seed, not counting stalks and leaves—there are 13.57 pounds of nitrogen, 5.45 pounds phosphoric acid, and 5.7 pounds potash.

Compare these figures with the amounts of plant food usually supplied in commercial fertilizers. The man who uses two hundred pounds of 8—2—2 goods on his cotton crop, applies four pounds of nitrogen, sixteen pounds phosphoric acid, and four pounds potash to an acre of land. That is, if he raises an average crop of cotton, he removes over three times as much nitrogen, one-third as much phosphoric acid, and more than as much potash as he supplies to the land. When, as is often the case, no other provision is made to keep up the sup-

plies of plant food, is it any wonder that many lands grow steadily poorer and produce smaller crops with each succeeding year? In fact, if the matter is considered simply from this standpoint, the wonder would be that all soils were not speedily brought down to a state where they would be unable to produce profitable yields. It is to be remembered, however, that very few crops are entirely removed from the land on which they grow, and that in any well considered system of farming there is a constant return to the soil of the products taken from it. Every good crop rotation is planned with this idea of returning to the soil just as much as possible of the plant food removed from it by the crops. And this means that in a good farm rotation the growing of crops to feed to live stock is made a leading feature.

#### **GROWING GOOD CROPS WHILE BUILDING UP THE SOIL.**

If a farmer took away from the land all that he grew upon it one year after another, it would be only a question of a few years until any ordinary soil would be unable to yield enough to pay him for the labor of making the crop. On the other hand, by judicious rotation, the feeding of live stock, and the purchase of such commercial fertilizers as are actually needed, he may continue to build up his land and at the same time grow upon it large crops every year.

The difference in the drain upon the soil by different systems of farming is a matter to which every farmer must give earnest consideration. The man who sells a ton of wheat removes from his land, 47.2 pounds of

nitrogen, 17.8 pounds of phosphoric acid, and 12.2 pounds of potash. At present commercial prices these plant foods would cost over \$11. On the other hand, the man who sells a ton of butter takes from his land only a few cents' worth of the essential plant foods. If the cotton grower who produces a bale to the acre sold both lint and seed from his farm, he would take away 36.2 pounds of nitrogen, 14.3 pounds of phosphoric acid, and 15 pounds of potash from each acre of land. If he sold the lint only and fed the seed to live stock and returned the manure to the land he might expect to give back to the soil at least two-thirds of the plant food contained in the seed. In this case he would remove only 13.2 pounds of nitrogen, 5.1 pounds of phosphoric acid, and 6.5 pounds of potash.

This loss could easily be made good by growing after the cotton a crop of crimson clover to which had been applied 100 pounds to the acre of a fertilizer analyzing 5.1 per cent phosphoric acid and 6.5 per cent potash. In other words, the cotton farmer who sells both lint and seed off his farm makes a terrific drain upon soil fertility, while the farmer who sells only the lint and feeds the seed to live stock can, by the use of comparatively small quantities of the cheaper plant foods, keep his soil constantly improving in fertility.

#### ROTATION AND SOIL FERTILITY.

The matter of keeping up soil fertility is much more largely a matter of crop rotation and soil management than of the use of commercial fertilizers, although these

must be used in any system of farming if the total supply of the mineral elements in the soil is not to be reduced. To put it briefly, the maintenance of soil fertility depends in the first place upon the kind of farming that is followed, the crops that are sold from the land, and the returns made to it from the feeding of these crops to live stock, and only secondarily and to a very much smaller degree, upon the fertilizers that are supplied to the various crops grown upon it.

## CHAPTER XIV.

### HOW GREEN MANURES BENEFIT THE SOIL.

**W**HY IT IS NOT the part of wisdom to depend entirely upon commercial fertilizers to keep up the fertility of the soil, has already been explained; and the necessity of green and stable manures has been pointed out. These are valuable not only for the plant food they contain, but even more for the effect they have upon the texture of the soil, and for the humus they add to it. Since a liberal supply of humus in the soil is necessary to enable any crop to do its best, or to enable any fertilizer to give the best results, it is easily seen that no farmer who would keep his land constantly growing better—as every farmer should—can afford to neglect either green or stable manures.

Green plants are usually about 80 per cent water. The dry matter is mostly cellulose or starch, and cellulose and starch are made up of carbon, hydrogen and oxygen, which the plant obtains from the air and water and of which there are unlimited supplies. This means that when a grain or grass crop is turned down, there is added to the soil no more of the three plant foods commonly lacking than was already in it. Yet every farmer knows that most land is greatly improved by having vegetable matter of any kind mixed with it.

#### GREEN CROPS MAKE PLANT FOODS MORE AVAILABLE.

The reasons for this are largely to be found in what has been said about humus and the physical condition of

the soil; for these green crops as they decay supply the soil with humus; enable it to hold more moisture without becoming too wet for plants to do well; retain this moisture better in a dry time; lighten the soil, thus permitting of a freer circulation of air; furnish food for the soil bacteria to feed on, and by improving the texture of the soil, enable the roots of the crops that may be growing on it to gather larger supplies of food. That is, while the turned-down green crop does not add to the supplies of plant food in the soil, it makes it easier for the growing crops to get what is there.

It does this, not only by keeping the soil in better tilth and holding more moisture for the use of the plants, but also, as has been said, by furnishing more food for the soil bacteria. These exceedingly minute plants are what causes the vegetable matter in the soil to decay. They draw the food for their growth from it, and as they die leave this food in such shape that it can be dissolved in the soil water and used by the crops planted on the land. Their growth and death also help to make more available some of the other plant foods, since as has been stated, it is only when this food is in such form that it can be dissolved by the soil moisture that it can be of service to the farmer.

#### **LEGUMES ADD NITROGEN AS WELL AS HELP BACTERIA.**

But while the crop of rye or grass does not add to the supply of nitrogen, phosphoric acid or potash in the soil, there are some crops that do add largely to its supply of nitrogen. These crops are what we call legumes, and

include all the clovers, alfalfa, the vetches, all our beans and peas, the lupines and other crops less well known. The different locust trees and the red-bud are also legumes.

These legumes get much of the nitrogen used in their growth from the air, so that when they are returned to the land on which they grew, or even when only the roots and stubble are left, there is a distinct increase in the soil's supply of nitrogen. This nitrogen is obtained from the air by the aid of certain bacteria which live upon the roots of the plants in question. The bacteria have the power of taking the nitrogen needed for the growth directly from the air in the inter-soil spaces, and as they die, this nitrogen may be used by the plant upon which they are growing.

#### **NODULES INDICATE NITROGEN-GATHERING BACTERIA.**

By pulling up a healthy cowpea or clover plant, little lumps, or nodules, may be seen on its roots. These nodules are the homes of millions of these nitrogen-gathering bacteria, and by their size and number one can form an idea of the work the crop is doing in adding to the nitrogen contents of the soil.

Sometimes none of these nodules will be found, for the bacteria that live on the various plants do not seem to be present in all soils. When these bacteria are not present—that is, when the nodules are not found on the roots of the crop, it seldom thrives as it should and, of course, does not add to the nitrogen in the soil.

### WHY WE INOCULATE LAND.

Different kinds of bacteria live on different plants; and one legume may be well supplied with these nodules on land where some other crop shows no trace of them. Thus the bacteria that live on the roots of the cowpea seem to be abundant all over the South, while those that grow on crimson clover are not present in many soils. In such cases, it is necessary to "inoculate" the soil—that is, to supply it with these bacteria, before the crop can be of value to the farmer as a gatherer of nitrogen from the air. This inoculation may be done by spreading soil from a field where the bacteria are known to exist over the land in which they seem to be lacking, or by the use of "cultures" of these bacteria. These cultures are simply preparations, usually of some jelly-like substance, in which the bacteria have been grown in great numbers. Ordinarily, the soil method of inoculation is the surest and best.

### SUMMARY.

Green manures, then, are crops of any kind returned to the soil on which they grew. They may, of course, be applied to other soils, and they may be allowed to mature or to die before being mixed with the soils, or be used while still green. They (1) supply humus, (2) improve the texture of the soil, and (3) in the case of the legumes, add to it nitrogen, which is taken from the air.

## CHAPTER XV.

### WHEN AND HOW TO USE GREEN MANURES.

**A** PART of almost every crop that is grown is returned directly to the soil and thus becomes a green manure; but the crops grown especially for this purpose are comparatively few. Those most commonly grown in the South are cowpeas, crimson clover, bur clover, and rye. In some sections red clover is also a highly-prized green manuring crop, and large areas of lespedeza—Japan clover—are also utilized this way. Other winter crops sometimes used are the vetches, turnips, and wheat or oats. Of these, the cowpea and Japan clover are summer-growing crops, red clover is a biennial—that is, lasts two years,—the others are winter-growing crops.

### THE BEST WAY TO USE MANURE CROPS.

All of these crops are valuable for feed; and as a general proposition, it may be said that any crop that can be profitably fed to live stock will pay better when so used than when returned directly to the soil. This is because when the crop is fed the feed value is, of course, secured, and there may be saved in the manure from 60 to 85 per cent of the plant food that was originally in the crop. This plant food, too, is usually in a more readily available condition for the use of the following crop in the manure than in the turned-under crop.

The ideal way, then, to utilize crops grown for manuring is to feed them to stock and to return the manure to

the soil, thus securing their full feeding value and from two-thirds to three-fourths of their original fertilizer value.

While this is true as a general proposition, however, the fact remains that it will often pay to return a crop directly to the land on which it was grown—that is, to plow it down or otherwise incorporate it with the soil before or after maturity. The cases when this is advisable will mostly fall under three heads.

#### WHEN IT PAYS TO PLOW UNDER A GREEN CROP.

The first is when the crop is so light that the expense of harvesting it would amount to more than its value as a feedstuff. Such cases are very common on the poorer lands of the South. Many old fields can be most economically started on the way of improvement by sowing a crop of cowpeas, for example, in the spring, fertilizing this crop with phosphoric acid and potash if these elements are needed, working it into the soil when mature, and following it with a winter crop, like rye or crimson clover, to be turned under also before anything is removed from the soil. This is, however, a plan to be recommended only on very poor lands much lacking in humus, or under other exceptional circumstances.

The second case in which the direct application of a crop as a green manure is to be advised, is where the land needs the humus and there is little chance of its being returned to the soil if the crop is removed. If the owner of the land, for example, has not the stock to which to feed a crop of cowpeas and can only sell the hay and buy

commercial fertilizers to feed his land, it may pay him to plow the crop under, even though he could sell it and buy more plant food in other forms after getting pay for the extra work of saving and marketing the crop. This scarcity of live stock to consume the crops grown makes green manuring a necessity in many cases where it would be much better if the crop could be first fed.

A third case is where if the fertilizing crop is left to mature it will be in the way of a succeeding crop. For example, if a cover crop of rye is to be followed by cotton, it may be necessary to plow the rye under before it makes growth enough to make its harvesting profitable. A similar problem is often presented with winter-growing crops, such as rye and crimson clover, that while useful for feed to a certain extent, have also some features that make their use objectionable. Rye is an excellent crop for cutting and feeding green; but if it must be made into hay, it will usually pay better to plow it down. Crimson clover makes good hay if cut at exactly the right stage; but if allowed to get too ripe, it may be a dangerous feed, especially for horses, and in such cases, is best plowed under.

#### **SOME POINTS TO OBSERVE IN USING GREEN MANURES.**

The great value of green manures in adding to the humus of the soil has been spoken of; but they sometimes produce injurious effects also and, like other fertilizers, must always be used with reference to the crop that is to follow their application.

The plowing under of a larger amount of vegetable mat-

ter as a preparation for, or a short time before, the sowing of wheat or oats in the fall, is never to be advised. The undecayed mass makes the soil "puffy" and unsettled and prevents the formation of that fine, firm seed bed which these crops so much like. Indeed, it is nearly always better to have green manures mixed with the soil in time for them to have partially decayed, at least, before the succeeding crop is planted. This is not always practicable, however, and with some crops, corn for example, is not of great importance. The plowing under of a heavy crop of green vegetation often results in too much acidity in the soil when it begins to decay. For this reason it is usually better when a rank crop is to be turned down to allow it to fully mature. Soil acidity produced by this may be corrected, however, by giving the soil a top dressing of lime after the crop has been plowed down. Green manures are most profitably used as a preparation for such gross-feeding and humus-needing crops as corn, or for those, like the Irish potato, and other root crops, that need plenty of soil moisture, do not mind a little sourness in the soil, and are sometimes injured by the application of stable manures.

#### COVER CROPS FOR GREEN MANURING.

The crops most generally profitable as green manures are those that are grown during the winter to protect the soil, and are then turned down in the spring in time to be followed by cotton, corn or other hoed crops. Rye, for example, is most profitably used, as a rule, by pasturing or soiling in the early spring and then turning under;

while it is often more profitable to plow a crop of crimson clover in for the benefit of the corn crop that is to follow than to try to make hay of it. A summer-growing crop, such as the cowpea, should, on the other hand, be first used as a feed, unless the land is very poor indeed, or there is no other chance of getting the humus the crop contains into the soil.

To sum up then: (1) The most profitable green manuring crops, as a general rule, are those that grow during the winter and are turned down in the spring; (2) It is usually better, when practicable, to let a crop mature than to plow it in green; (3) Large quantities of green matter turned under sometimes sour the soil and are always objectionable just before seeding oats or wheat; (4) Where a crop can be profitably saved for feed and the manure returned to the land this should always be done.

## CHAPTER XVI.

### MAKING AND CARING FOR STABLE MANURE.

**T**HE THREEFOLD value of stable manures— (1) in improving the texture of the soil, (2) in promoting bacterial activity, and (3) in adding to the available plant food in the soil—has already been spoken of, and all that was said in the last chapter about the benefits of green manures applies with even more force to stable manures.

Manures contain nothing that was not in the feed the animals consumed; but these feeds have been changed, both in their physical condition and their chemical composition, by the processes of digestion, so that they are, as a rule, more quickly effective and more marked in their effects than green manures. Stable manures, indeed, may be said to be the basis of all really scientific and practical fertilization. There are, of course, exceptions to this rule—for example, they should not be applied directly to some crops—but it is a safe general proposition. The general farmer should use commercial fertilizers as supplements to his home-produced manure, and not as substitutes for it.

#### STABLE MANURES THE CHEAPEST FERTILIZERS.

The economy of feeding a great part of the crops grown on the land to live stock, of getting the full feeding value of these crops and then of returning from two-thirds to three-fourths of the fertilizing elements in them to the soil in a readily available and permanently helpful form,

must be apparent to any one. Then, when it is remembered that cultivation always has a tendency to reduce the humus supply in the soil, that this supply must be kept up if the producing ability of the land is to be maintained or increased, and that commercial fertilizers do practically nothing toward keeping up this supply, the folly of any one's engaging in general farming without paying due attention to both the production and the care of stable manures would seem to be too evident to be overlooked.

#### WHAT STABLE MANURES CONTAIN.

As already stated, the value of the manure produced by an animal depends upon the feed the animal has had. There is in the manure that part of the feed materials which the animal has failed to assimilate and the waste products of its body that have been thrown off and expelled with this unused material.

For this reason stable manures vary constantly and considerably in composition. The analyses usually published are averages of a great many, and the composition of any particular lot of manure may be very different from that indicated by these averages. The thing for the feeder to remember is, that feeding with "rich," nutritious feeds will produce manure rich in plant foods, while feeding with feeds low in nutriment can only produce manure of poor quality.

The following table gives some analyses which may be taken as representing a fair average of the composition of stable manures:

	Per ct. Nitrogen.	Per ct. Phos ac.	Per ct. Pot.
Cattle, solid, .....	0.29	0.17	0.10
Cattle, urine, .....	0.58	....	0.49
Cattle, mixed, .....	0.44	0.16	0.40
Horse, solid, .....	0.44	0.17	0.35
Horse, urine, .....	1.55	....	1.50
Horse, mixed, .....	0.58	0.28	0.53
Swine, mixed, .....	0.45	0.19	0.60
Sheep, solid, .....	0.55	0.31	0.15
Barnyard, mixed, .....	0.49	0.32	0.43
Hen .....	1.10	0.85	0.56

In other words, a ton of average horse manure contains plant food worth about \$3.18, and a ton of cow manure contains about \$2.36 worth.

Every practical farmer knows, however, that for most crops and on most soils a ton of manure is worth much more, and it has already been explained why this is so.

#### HOW MANURE IS WASTED.

Notwithstanding the great value of stable manure and the very limited supply on most farms, it is unfortunately true that a large per cent of the plant food in it is wasted instead of being returned to the soil, and in many cases much of the humus-forming and bacteria-aiding benefit that might be obtained from it is lost.

Whenever manure is left exposed to the weather the soluble plant foods in it are quickly washed out by rains. If it is on the land where it is needed, this does not matter, as the plant foods will be taken into the soil; but if the manure is lying in a hard-packed barnyard that drains into a gully or creek, the best part of it is largely

lost. Many farmers imagine that the manure left by their stock on the pasture is of little benefit, while the truth is that they probably get a much larger proportionate benefit from it than from that which is dropped in the stables. This is certainly true if this latter is thrown out under the eaves of the barn or allowed to get hot and dry and "fire-fang." Few farmers have any real idea of the great loss which occurs from their careless method of handling manure. "Experiments made by Roberts show that when horse manure is thrown in a loose pile and subjected to the joint action of leaching and weathering, it may lose in six months nearly 60 per cent of its most valuable fertilizing constituents." When the liquid manure is wasted, as is so often the case, fully two-thirds of the nitrogen and a large part of the potash in the manure are lost.

Whenever manure is allowed to "heat" until the sharp, acrid scent of escaping ammonia can be noticed, the farmer is losing money again, for the most valuable plant food in it is escaping into the air. In fact, whenever decomposition sets in, there is likely to be some loss of ammonia. The mixing of lime or ashes with manure also tends to liberate the ammonia in it, and should never be practiced.

#### WHY MANURE SHOULD BE SPREAD AS MADE.

For these reasons, the sooner manure can be applied to the soil after it is made, as a general rule, the better. For some crops, it may pay to keep the manure until it is well rotted before using it; but for ordinary farm crops

it does not pay, and there is always more or less loss of plant food. Where it can be done, the manure should be taken from the stables to the field every day. Where this is impossible, the best thing is to keep it tightly packed, with plenty of bedding under the feet of the stock, always having it moist enough to prevent heating. If it must be kept in heaps, they should be rather low and flat, so as to offer as little exposure to the air as possible, and should be kept very moist. The use of absorbents in the stalls to take up the liquid manure is a necessity if its full value is to be obtained. Plenty of bedding is demanded wherever concrete gutters and floors are not used, and the use of "floats" or acid phosphate in the stalls also helps to retain the urine—the most valuable part of the manure—and also to balance it up in the element in which it is most lacking, phosphoric acid. Excellent bedding materials are straw, leaves, cut-up corn stalks, cottonseed hulls—anything, in fact, that will absorb and hold the liquid manure.

As a general thing, the less handling that can be given the manure and the quicker it can be put on the land after it is made, the better. Aside from the use of plenty of bedding and some such absorbent as those here recommended, it seldom pays to "compost" manures—exceptions will be noted in the next chapter—and the "formulas" for mixing manure with various chemicals, etc., may be grouped together as frauds. All are unprofitable and many positively injurious and the wise farmer will not waste time, labor and often plant food, by repeated and unnecessary handling of his manure.

## CHAPTER XVII.

### HOW AND WHEN TO APPLY STABLE MANURE.

**T**HE CROPS on which stable manure gives the most marked immediate returns are those that have a strong root system and that require comparatively large amounts of nitrogen. Crops that need especially large amounts of water during the summer season, when it is likely to be hot and dry, are also greatly benefitted by the use of plenty of stable manure. The corn crop comes in both these classes and is a favorite, and a decidedly good, place to use the farm's supply of stable manure.

But the effects of the judicious application of stable manure are so generally beneficial that it is easier to say where it should not be used than where it should.

### WHERE NOT TO USE STABLE MANURE.

It is poor economy, then, to apply stable manure to leguminous crops, because it is richest in nitrogen, the element which it is the special mission of these crops to get from the air. An exception to this rule may be the case where, on poor land, stable manure is of great service in getting a start, especially of alfalfa; but even here it is likely that in most cases it would pay to inoculate the soil and to use the stable manure elsewhere.

Fresh stable manure should not be applied to root crops—beets, carrots, etc., or to potatoes. It tends to make the root crops grow rough and forked, and favors the growth of scab upon the potatoes. The manuring of the land is an excellent preparation for any of these crops

but the manure should be put on several months before they are planted—the fall before is a good time.

For such vegetables as lettuce, cauliflower, etc., where a very rapid growth is desired, manure may be used in connection with other fertilizers, but it should always be well rotted before it is applied and thoroughly mixed with the soil. It probably pays to compost the manure with sods and sand for these crops, and for potted plants, greenhouse beds, and so on; but aside from this, composting is usually a waste of labor if it is possible to apply the manure direct.

#### MANURE NOT A PERFECT RATION FOR MOST CROPS.

A heavy application of manure to oats or wheat may cause too great a growth of straw, if it is not supplemented with other fertilizers containing phosphoric acid and potash. Indeed, manure is for most crops on most soils a very badly balanced ration, and needs to be evened up with liberal supplies of the mineral elements. On most soils, however, the manure is of such great benefit as a supplier of humus and a promoter of bacterial activity, that it should be the main dependence as a fertilizer, the commercial fertilizers being used as needed to balance it.

In the stock-raising sections stable manure alone is often depended on to keep up the soil fertility, with the result that the soil is gradually depleted of phosphoric acid. This is incomparably better, however, than the common Southern practice of depending upon commercial fertilizers and exhausting the soil's supply of humus and nitrogen.

### HOW TO APPLY MANURE.

Manure should in most cases—in practically all cases, it is safe to say—be applied broadcast. The scattering of small amounts in the drill or row is a wasteful and unprofitable practice. If enough is put in to be of any marked value as a source of plant food, there is danger, unless it is very fine, that it may dry out and “fire” the crop if a drouth comes. If the manure is made fine and mixed with the soil, it will decay and aid greatly in the holding of moisture. This fining of manure is another point that needs emphasizing. A big lump of manure is of comparatively little use to the plants, because the plant food in it is held so that it cannot be dissolved by the soil water. It is a mere clod, and it is possible for a plant to starve among the richest sort of clods.

These, then, are the two great points to be remembered in applying manure:

(1) It should be made as fine as possible, and (2) mixed thoroughly and uniformly through the soil.

The manure spreader has made it much easier to get the manure out on the soil, and has enabled it to be put there in much better shape than was possible by hand. Manure should never be piled in small heaps in the field, as it is sure to lose much of its nitrogen when left in this shape. When taken to the field the proper thing is to spread it on the land at once.

### WHERE MANURE IS LIKELY TO GIVE BEST RETURNS.

As to where the manure should be used, it is merely a question of the best place, since it is needed nearly

everywhere and practically on all our staple crops. The corn field is one of the best places; the cotton field will be greatly profited by it; it may be spread thinly as a top dressing in the winter on grain and grass fields and made to yield great returns; it is needed in the orchard, in the garden, and on the lawn.

All soils seem to profit by it, too. While its effects are most marked on soils lacking in nitrogen and on those of a tight clayey nature, it gives good returns even on rich alluvial soils and on newly cleared forest lands.

Most Southern farmers, will however, probably find it most profitable to broadcast their manure for the corn and cotton crop; and to use it in the garden and on trucking crops. When the soil is what is usually called "rich"—that is, well supplied with nitrogen—it may produce too great a growth of stalk and leaves if used alone, but this can always be counteracted by the addition of phosphoric acid and, on soils needing it, potash for grain crops or cotton, and by phosphoric acid and potash for fruits, potatoes and root crops.

No other fertilizer is so much needed by most Southern soils, and not until stable manure, rather than commercial fertilizers, is looked upon as the great essential to the maintenance of a fertile soil, will it be possible to economically build up the waste lands of the South. For this reason it is the part of wisdom for the farmer to make as much manure as he can, to take the best possible care of it so as to prevent the waste of any of the fertility it contains, and to apply it to the soil as fast as is convenient so that the crops may be using it.

## CHAPTER XVIII.

### THE PROFITABLE USE OF LIME.

**W**HILE IT is common to speak of lime as a fertilizer, it is in reality seldom used to supply any actual lack of calcium, the plant food which it contains. Most soils contain enough of this element for all the needs of ordinary crops. The true purposes of lime usually are to correct soil acidity and to improve the physical condition of the soil. This latter is accomplished on clay soils by flocculation, or the breaking apart of the soil particles; while in sandy soil the lime tends to bind the larger soil grains together and thus increases the moisture-holding capacity of the soil. Lime also aids in the nitrification of humus compounds in the soil, and helps to release potash so that it may be used by the plants.

It will thus be seen that lime may do great good or great harm, as it is used with judgment or at hazard. Where it is used solely to make more available the plant food already in the soil and is thus made a sort of substitute for rational fertilization, the effect of its work in making more available the nitrogen and potash in the soil must, in the long run, be to deplete the soil, and after a few years of better crops, to reduce its productive capacity. Such use as this gave rise to the old saying, "Lime makes the father rich and the son poor."

#### WHERE LIME IS NEEDED.

Used, however, at intervals of four or five years, and in only sufficient quantities to keep the soil sweet, to

promote bacterial activity and to assist in keeping the land in good tilth, lime may pay handsome profits to the user. There is this to be remembered in all cases, however: It does not pay to use lime often or in large quantities, unless the humus supply of the soil is kept up. This means that the lime should be used in a sort of rotation with green or stable manures.

Lime is needed to correct soil acidity on large areas of Southern lands. The growth of such weeds as sorrel, the crowding out of the tame grasses by broomsedge, the failure of alfalfa or the clovers to grow, are often indications of acidity. The simplest test is to take a piece of blue litmus paper, moisten a batch of soil thoroughly and leave the litmus paper in contact with it for an hour or so. If the paper turns pink, it is safe to say that the soil needs lime.

Lime is generally applied broadcast to the soil, and worked lightly into it. It may be sown with a manure spreader, or with machines made especially for this purpose.

It is generally applied after the soil has been broken and before the crop has been planted, though it may be sown directly on grass lands and harrowed in. Fall and spring are the usual seasons of application, though when a green crop has been turned down, it is often advisable to follow it with a top dressing of lime.

Among the crops that will not thrive on a sour soil are alfalfa, the clovers, bluegrass, and the peanut. Indeed, few of our staple crops do their best on a soil that is to any marked degree acid, and lime has been profitably

used for corn, tobacco, cotton, the small grains and most vegetables. This does not mean that it will pay in every case to use lime for these crops. The soil condition is always the first thing to consider when the question of whether or not to use lime comes up.

#### THE FORMS IN WHICH LIME MAY BE HAD.

Lime may be had in various forms—as a carbonate in ashes or in ground limestone; as a hydrate in water-slaked lime, and as a caustic lime or oxide in burnt limestone, shells or bone.

Sulphate of lime is obtained when gypsum or acid phosphate is used, but this form has little effect on soil acidity.

The burnt lime is the most active form, but by using larger quantities of other forms the same results may be obtained. To equal 100 pounds of caustic lime will require about 132 pounds of the hydrated, or water-slaked lime, or 178 pounds of ground limestone. Burnt lime that is allowed to air-slake, has practically the same composition as the ground limestone. Therefore, if caustic lime costs \$5 per ton, hydrated lime should sell for about \$3.75, and ground limestone for about \$2.85 per ton. Experiments indicate that the use of ground limestone will have less tendency to burn out the humus supply in the soil than will that of caustic lime, though there is much yet to learn on this point.

#### SEVEN RULES TO REMEMBER.

A few of the rules to be followed in using lime may be briefly given:

(1) Lime should be used only when soil conditions seem to call for it, and must not be regarded as a substitute for fertilizers.

(2) Lime promotes nitrification and bacterial activity in the soil. It will, therefore, tend to dissipate the supply of humus in the soil, unless used in connection with green or stable manures.

(3) Lime, or any of the fertilizers in which it is found in an active form, should not be mixed with any material containing nitrogen, since it tends to set it free and permits its being wasted. That is, lime, ashes, basic slag, should not be mixed with stable manure, cottonseed meal, nitrate of soda, or any of the nitrogenous fertilizers.

(4) It is, as a rule, better to use comparatively small quantities—10 to 15 bushels per acre—once in three or four years, than to apply very large quantities at once. An exception to this is where the soil is very sour and needs correction at once.

(5) Lime should not be used on Irish potatoes, as it favors the development of the scab.

(6) In applying lime it is only necessary to work it very lightly into the surface of the soil.

7. It should usually be applied a week or two weeks before the seed are planted.

## APPENDIX.

### PLANT FOOD IN TYPICAL SOILS.

**W**HILE the chemical analysis of a soil can, at the most, give only a general idea of its needs in the way of fertilizers, and is by no means—as so many people seem to think—an accurate or even a safe guide as to its fertilization for any crop, a few typical soil analyses may be of interest.

The following are analyses of Tennessee soils made by Prof. Chas. A. Mooers, of the State Experiment Station:

Type of Soil	Description	Humus	Nit.	Phos. Acid	Pot.	Lime
Dolomite -----	Ridge land, poor-----	0.75	0.08	0.03	0.14	0.09
Dolomite -----	Valley, rich-----	0.76	0.11	0.09	0.28	0.17
Shale -----	"Crawfishy"-----	0.66	0.07	0.02	0.08	0.09
Limestone -----	Very rich-----	2.42	0.31	0.10	0.85	0.82
Limestone -----	Meadow land-----	1.87	0.21	0.15	0.43	0.56
Limestone -----	Virgin soil-----	0.74	0.09	0.04	0.15	0.10
Limestone -----	Subsoil of last-----	0.27	0.04	0.03	0.12	0.04

The following compositions of typical soils, gathered from various sources will further show the great differences in the amount of plant foods contained in soils of various types:

	Humus	Nit.	Phos Acid	Pct:	Lime
Virgin prairie .....	5.12	0.38	0.35	0.45	0.69
Pine forest .....	0.47	0.04	0.13	0.16	0.47
Oak forest .....	2.48	0.24	0.30	0.26	0.76
Average 200 fertile .....	3.35	0.29	0.24	0.21	2.16

The percentage of lime in the last case may seem remarkably high, but a Red River valley soil, contained in the surface soil, 2.44 per cent of lime and in the sub-soil 7.45 per cent.

#### WHAT CROPS TAKE FROM THE SOIL.

The following tables showing the amount of plant foods removed from the soil by different crops should prove suggestive to the farmer who wishes to maintain the fertility of his land. For a cotton crop making 100 pounds of lint per acre, Professor Massey estimates that the following amounts of plant food will be required:

	Nit.	Phos. Acid	Potash	Lime
Roots (83 lbs.) .....	0.76	0.43	1.06	0.53
Stems (219 lbs.) .....	3.20	1.29	3.09	2.12
Leaves (192 lbs.) .....	6.16	2.28	3.46	8.52
Bolls (135 lbs.) .....	3.43	1.30	2.44	0.69
Seed (218 lbs.) .....	6.82	2.77	2.55	0.55
Lint (100 lbs.) .....	0.34	0.10	0.46	0.19
Total pounds per acre .....	20.71	8.17	13.06	12.60

The following estimates of the drain of other staple crops are taken from Prof. C. W. Burkett's "Soils":

		Nit.	Phos. Acid	Potash
Corn	50 bushels grain .....	40.9	19.6	11.2
	2 tons stover .....	41.6	11.6	76.0
Wheat	25 bushels grain .....	35.4	11.8	7.5
	1½ tons straw .....	17.7	3.6	15.3

Two hundred bushels of Irish potatoes will remove 25.6 pounds of nitrogen, 8.4 pounds of phosphoric acid and 34.8 pounds of potash; and 200 bushels of sweet potatoes, 28.8 pounds of nitrogen, 9.6 pounds of phosphoric acid, and 44.4 pounds of potash. This is supposing that all the tops are left on the land.

A ton of tomatoes would remove 3.2 pounds of nitrogen, 0.1 pound of phosphoric acid, and 5.4 pounds of potash, while in a ton of apples there would be only 2.6 pounds of nitrogen, 0.2 pound of phosphoric acid, and 3.8 pounds of potash.

A ton of well cured cowpea hay will contain 39 pounds of nitrogen, 10.4 pounds of phosphoric acid, and 29.4 pounds of potash, a ton of soy bean hay, 46.4 pounds of nitrogen, 13.4 pounds of phosphoric acid, and 21.6 pounds of potash. The nitrogen in these two crops will, however, have been obtained chiefly, or altogether, from the air so that only the mineral elements need to be taken into account in considering their drain upon the soil.

It may be said that none of the above figures can be

taken as absolute, though all are correct enough to serve as guides. No two analyses of any grain or plant are likely to be exactly the same, and allowance must always be made for this variation. In considering whole crops even greater allowances must be made as no two corn crops are likely to have exactly the same proportion of grain to stover, or no two cotton crops the same proportion of lint to stalk and leaves.

#### WHAT SOME HAY CROPS TOOK AWAY.

Here is an interesting table showing the amounts of plant food in some crops actually grown—roots and tops. The first column gives the pounds of dry matter in the crop and the following the pounds of the various plant foods:

	Dry matter	Nit	Phos. Acid	Potash	Lime
Red clover.....	7,438	143.7	39.6	156.6	98.3
White clover .....	6,349	173.8	51.0	179.4	95.6
Alsike .....	5,910	119.8	36.1	155.9	86.1
Crimson clover .....	4,604	108.3	24.6	97.9	84.9
Timothy .....	6,281	47.0	27.5	78.0	35.5

This shows the heavy drain the legumes make upon the potash, lime, and phosphoric acid in the soil, and also their great value to the farmer in gathering nitrogen. To supply as much nitrogen as was in this crop of white clover would have required 1,085 pounds of nitrate of soda; and nearly all this nitrogen was taken from the air. The timothy crop, weighing practically as much, con-

tained less than one-fourth as much nitrogen, and all this was taken from the soil.

The moral is: To have rich soils and well fed stock, apply plenty of the mineral elements to the land and grow legumes.

### FERTILIZING MATERIALS IN FEEDING STUFFS.

The following analyses show the percentages of the three important plant foods in some of the most commonly used feedstuffs. Remember what has already been said about the constant variability in the analyses of all organic substances:

Green Fodders	Nitrogen	Phos. Acid	Potash
Corn fodder .....	0.41	0.15	0.33
Sorghum fodder.....	0.23	0.09	0.23
Rye straw, green.....	0.33	0.15	0.73
Millet.....	0.61	0.19	0.41
Timothy.....	0.48	0.26	0.76
Red clover.....	0.53	0.15	0.46
White clover.....	0.56	0.20	0.24
Alsike.....	0.44	0.11	0.20
Crimson clover.....	0.43	0.13	0.40
Alfalfa.....	0.72	0.13	0.56
Cowpea.....	0.27	0.10	0.31
Soy bean.....	0.29	0.15	0.53
Winter vetch.....	0.59	0.19	0.70
Corn silage.....	0.28	0.11	0.75

Seeds	Nitrogen	Phos. Acid	Potash
Corn-----	1.82	0.70	0.40
Buckwheat-----	1.44	0.44	0.21
Soy beans-----	5.30	1.87	1.99
Cottonseed-----	3.13	1.27	1.17
Sorghum seed-----	1.48	0.81	0.42
Oats-----	2.06	0.82	0.62
Wheat-----	2.36	0.89	0.61
Rye-----	1.76	0.82	0.54
Rice-----	1.08	0.18	0.09
By-Products			
Corn cobs-----	0.50	0.06	0.60
Gluten meal-----	5.03	0.33	0.05
Wheat bran-----	2.67	2.89	1.61
Wheat middlings-----	2.63	0.95	0.63
Rice bran-----	0.71	0.29	0.24
Rice polish-----	1.97	2.67	0.71
Cottonseed meal-----	6.97	2.88	1.87
Cottonseed hulls-----	0.69	0.25	1.02

## ANALYSES OF FERTILIZING MATERIALS.

This table gives average compositions of the most commonly used fertilizing materials:

Materials	Percent Nitrogen	Percent Phos. Acid	Percent Potash
Nitrate of soda.....	15.5 to 16		
Sulphate of ammonia.....	19 to 20.5		
Dried blood, high-grade.....	12 to 14		
Concentrated tankage.....	11 to 12.5	1 to 2	
Dry fish scrap.....	7 to 9	6 to 8	
Cottonseed meal.....	6.2 to 7.2	2 to 3	1.5 to 2
Phosphate rock.....		26 to 32	
Acid phosphate.....		12 to 16	
Bone black.....		32 to 36	
Ground bone.....	2.5 to 4.5	20 to 25	
Dissolved bone.....	2 to 3	1 to 17	
Thomas slag.....		18 to 23	
Muriate of potash.....			50
Sulphate of potash.....			48 to 50
Kainit.....			12.5
Sylvinit.....			16 to 20
Cotton hull ashes.....		7 to 9	20 to 30
Wood ashes, unleached.....		1 to 2	2 to 8
Wood ashes, leached.....		1 to 1.5	1 to 2
Tobacco stems.....	2 to 3	3 to 5	5 to 8

The composition of some of these substances is quite uniform. One buying muriate of potash, for example, counts on 50 per cent actual potash; nitrate of soda is expected to analyze 15.5 per cent nitrogen; a 16 per cent

acid phosphate can be had anywhere. But when organic substances,—cottonseed meal, tobacco refuse, dried blood, etc.,—are considered, there are likely to be wide variations in their compositions. A guaranteed analysis of these materials should always be insisted on.

### VALUE OF MANURE PRODUCED BY LIVE STOCK.

The Cornell Experiment Station estimates that the different farm animals will produce manure as follows:

Animal	Per 1,000 Pounds. Live Weight			
	Amount per day	Value per day	Value per year	Value per ton
Sheep .....	34.1 lbs.	7.2c	\$26.80	\$3.30
Calves .....	67.8 lbs.	6.2	22.63	2.18
Pigs .....	83.6 lbs.	16.7	60.95	3.29
Cows .....	74.1 lbs.	8.0	28.20	2.02
Horses .....	48.8 lbs.	7.6	27.74	2.21

These figures are, of course, only approximate or suggestive, as the value of the manure produced by any animal depends upon the feed it receives.

### COMPOSITION OF FARM MANURES.

The following analyses of farm manures are taken from Prof. W. F. Massey's "Practical Farming." Like all other analyses of organic substances, it must be remembered that they represent only the samples analyzed by one chemist, or else are averages of several analyses. It

is seldom that any two samples of manure will have the same analysis, and since the manure is only the unasimilated parts of the feed mixed with the waste products of the body, it is easy to see why this is so. This will explain the constantly varying analyses given for manurial products, and also explain why an animal poorly fed does not produce as much or as valuable manure as one fed on nutritious feeds:

	Nitrogen	Phos. Acid	Potash
Cattle excrement, solid, fresh.....	0.29	0.17	0.10
Cattle urine, fresh.....	0.58		0.49
Hen manure, fresh.....	1.10	0.85	0.56
Horse dung, solid.....	0.44	0.17	0.35
Horse urine.....	1.55		1.50
Human manure.....	1.00	1.09	0.25
Human urine.....	0.60	0.17	0.15
Pigeon, dry.....	3.20	1.90	1.00
Sheep dung, solid.....	0.55	0.31	1.15
Sheep urine, fresh.....	1.95	0.01	2.26
Swine dung, old.....	0.60	0.41	0.13
Barnyard manure, average.....	0.49	0.32	0.43

## TEN SAMPLE MIXTURES THAT ANY FARMER CAN MAKE.

The following list of fertilizer mixtures that may easily be put up at home, together with their analyses, may prove helpful for ready reference and suggestive of other combinations:

- (1) Cottonseed meal ..... 1,000 pounds  
 Acid phosphate (16 per cent) .. 1,000 pounds

Analysis: Phosphoric acid, 9.25 per cent; nitrogen, 3.1 per cent; potash, 0.75 per cent.

- (2) Cottonseed meal ..... 2 parts  
 Acid phosphate ..... 1 part

Analysis: Phosphoric acid, 7 per cent; nitrogen, 4.2 per cent; potash, 1 per cent.

- (3) Cottonseed meal ..... 1,000 pounds  
 Acid phosphate ..... 850 pounds  
 Muriate of potash..... 150 pounds

Analysis: Phosphoric acid, 8 per cent; nitrogen, 3.1 per cent; potash, 4.5 per cent.

- (4) Acid phosphate ..... 1,600 pounds  
 Kainit ..... 400 pounds

Analysis: Phosphoric acid, 12.8 per cent; potash, 2.5 per cent.

- (5) Acid phosphate ..... 1,600 pounds  
 Muriate of potash ..... 400 pounds

Analysis: Acid phosphate, 12.8 per cent; potash, 10 per cent.

- (6) Cottonseed meal..... 700 pounds  
 Acid phosphate ..... 1,200 pounds  
 Muriate of potash..... 100 pounds

Analysis: Phosphoric acid, 11 per cent; nitrogen, 2.1 per cent; potash, 3 per cent.

(7) Cottonseed meal .....	600 pounds
Acid phosphate .....	1,000 pounds
Kainit .....	300 pounds
Nirate of soda .....	100 pounds

Analysis: Phosphoric acid, 10 per cent; nitrogen, 2.6 per cent; potash, 2.3 per cent.

(8) Cottonseed meal.....	600 pounds
Nirate of soda.....	200 pounds
Acid phosphate.....	1,000 pounds
Muriate of potash.....	200 pounds

Analysis: Phosphoric acid, 8.7 per cent; nitrogen, 3.4 per cent; potash, 5.5 per cent.

(9) Dried blood (12 per cent).....	500 pounds
Nirate of soda .....	300 pounds
Phosphoric acid .....	900 pounds
Muriate of potash.....	300 pounds

Analysis: Phosphoric acid, 7.2 per cent; nitrogen, 5.3 per cent; potash, 7.5 per cent.

(10) Cottonseed meal .....	700 pounds
Nirate of soda.....	300 pounds
Acid phosphate .....	1,000 pounds

Analysis: Phosphoric acid, 8.5 per cent; nitrogen, 4.5 per cent; potash, 0.5 per cent.

These mixtures approximate, in their proportions, those most generally used, and by varying the quantities of the different materials, any desired analysis can readily be secured. It will be noticed that formulas very rich in

potash have been given, as well as those in which that element is very low. Also, that the formulas vary from No. 7, which is nearly the common 10—2—2, to the very rich mixtures in Nos. 9 and 10. No. 9 would be a fine potato or truck fertilizer in sections where potash is needed, while No. 10 would furnish plant food in a very concentrated form to the man whose soil does not need that element.

Cottonseed meal in these formulas is figured as containing 6.2 per cent nitrogen, 2.5 per cent phosphoric acid, and 1.5 per cent potash. A good grade will easily come up to this analysis, and many samples go above it. Always buy cottonseed meal, whether for fertilizing or feeding, by guaranteed analysis.













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