TEXAS AGRICULTURAL EXPERIMENT STATION

BULLETIN NO. 167 JUNE, 1914

DIVISION OF CHEMISTRY

# Commercial Fertilizers and Their Use

POSTOFFICE:
COLLEGE STATION, BRAZOS COUNTY, TEXAS

VON BOECKMANN-JONES CO., PRINTERS, AUSTIN, TEXAS

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BY


G. S. FRAPS, Ph. D.
STATE CHEMIST



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***In Cooperation with the Bureau of Plant Industry, United States Department of Agriculture.**

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# COMMERCIAL FERTILIZERS AND THEIR USE.

By G. S. Fraps, State Chemist and Chemist to the Experiment Station.

This bulletin has been prepared to aid those who use commercial fertilizers. We have endeavored to give as full information as possible. The fertilizer law and its operations are left to other bulletins, as an annual fertilizer control bulletin is issued by the State Chemist.

## FERTILIZERS SUPPLY PLANT FOOD.

It was learned about seventy-five years ago that plants are built up from certain materials which come from the air and from the soil, water being one of them. While about 95 per cent. of the dry plant comes from the air, this material is supplied by the air freely and abundantly to every plant. The case is, however, different with the soil. The soil does not always supply the plant with sufficient of the material necessary for its growth. The material necessary to the growth of the plant, we shall here term "plant food."

What food is essential to plants has been ascertained by growing the plant in water containing various materials which have been found in plants. If the plant grows well and produces seed abundantly without a certain material, that material is considered as not essential to the life of the plant. If, when all the other forms of plant food, or possible plant food are present, the plant does not do well in the absence of a certain material, this material is considered as essential to the life of plants.

The essential materials are ten in number. Seven come from the soil; namely, phosphoric acid, potash, nitrogen, sulphur, lime, magnesia, and iron. The plant secures carbon, hydrogen and oxygen from the water or the air; the water, of course, being taken up by the plant from the soil. Nitrogen is taken from the air by legumes, but all other kinds of plants are able to take it from the soil only.

When it was discovered that the plant, in order to grow well, must take up certain substances (called plant food) from the soil, attempts were immediately made to improve the quality of poor soils by the addition of various forms of plant food. Many of these attempts were very successful. This was the beginning of the use of commercial fertilizers.

It was found by various tests, made with the different kinds, that only three kinds of plant food need to be applied to soils. These three are phosphoric acid, potash, and nitrogen. Lime is sometimes applied, but the object of the application is not to provide an extra supply of plant food, but to bring about changes in the character of the soil, which render it more suitable for the growth of plants.

The application of plant food to the soil thus became confined to phosphoric acid, nitrogen, and potash. Commercial fertilizers contain phosphoric acid, potash or nitrogen, or mixtures of two of these, or all three.

Plants cannot readily secure phosphoric acid from all forms in which it may be applied; the same is true of nitrogen and potash. It is necessary to distinguish between plant food which can be readily taken up by plants, and that which can be taken up only with difficulty, or not at all.

Commercial fertilizers may be defined as materials which supply phosphoric acid, nitrogen or potash to the soil, in such forms that the plants can take them up readily.

### WHY SOILS NEED PLANT FOOD.

All soils contain some plant food, but it may be present in such form that plants cannot take it up readily.

Certain soils are naturally deficient in plant food even when first placed in cultivation; they do not supply a sufficient quantity of some one essential plant food to produce good crops. A great many soils of the Southern States are naturally deficient in phosphoric acid. This is particularly true of sandy soils.

If crops are grown and taken away, in time the fertility of even the richest soil will be depleted unless the plant food they take away is restored. A great many soils which were originally very productive have lost their fertility in this way.

Changes are going on in the soil which convert materials containing nitrogen into nitrates and ammonia. These can be taken up by plants, while the original nitrogenous matter cannot. Nitrates are very soluble in water and may be washed out of the soil. Under clean cultivation, considerable quantities of nitrogen have been known to be washed out; sometimes as much as 60 pounds per acre. Such loss would, of course, tend to deplete the store of nitrogen in the soil.

Truck crops, which must grow rapidly and mature early, have very heavy demands for plant food. Even fertile soils may not supply the necessary plant food with sufficient rapidity. With crops of this nature, the application of commercial fertilizers is usually profitable.

### PLANTS HAVE OTHER NEEDS BESIDES FOOD.

Plants have other needs besides the food supplied by the fertilizer. The best results with fertilizers are secured when the other needs of the plant are supplied as completely as possible.

Plants must have water, and an abundance of it. They require about 300 pounds of water for every pound of dry matter they produce. The supply of water is often the controlling factor in the growth of plants; in arid climates, the size of the crop has been found, within certain limits, to be directly proportional to the quantity of water supplied by irrigation. It is outside of the plan of this bulletin to discuss the methods of controlling the water in the soil.

Plants must have air. The roots of plants must have air, and air must enter the soil to oxidize organic matter, and aid in the preparation of food for plants.

The depth of soil, the treatment it receives, its physical condition and its character, the relation of the soil to drainage—these and other factors are important in the production of plants. Plant food is necessary, but other conditions are equally necessary.

Organic matter is needed by all soils. It has a favorable physical action on the soil, and in other respects adds to its productiveness. The addition of manure, or the use of green crops plowed under, should find a place in every plan for farm operation.

Fertilizers cannot take the place of good farming; they can only supplement good farming, and are most profitable when used in connection with it.

## HOW PLANTS ARE BUILT UP.

Chemistry teaches us that the materials of which the earth is composed can be split up, or decomposed, until we secure about seventy substances, which we are unable to break down; these substances, which cannot be decomposed into similar bodies, are called elements. By the union of two or more elements, compounds are formed. Most of the substances that we ordinarily see are compounds of two or more elements. A few are the elements themselves in a more or less impure form. Gold, silver, lead, iron, copper and sulphur are some elements with which we are familiar.

Plants are built up of a comparatively small number of elements. With two exceptions, plants are unable to take up and utilize elements as such; these exceptions are oxygen and nitrogen, both of which may be taken up in elementary form under certain conditions. The other materials of which the plant is composed, including all of those which are secured from the soil, must be taken up as compounds. Phosphorus, for example, is taken up as phosphoric acid. The element phosphorus is dangerous to handle; it takes fire when exposed to the air and must be preserved under water. It is also poisonous. Plants cannot take up elementary phosphorus, but phosphoric acid is essential to their life and development.

The element potassium is likewise unsuitable for the use of plants. It must be kept under oil. If thrown on the water, it will combine with the water, take fire and burn. Potassium in combination is, however, essential to plants.

## QUANTITY OF PLANT FOOD REQUIRED.

The following table shows the approximate amounts of plant food removed per acre by crops of the sizes given:

PLANT FOOD REMOVED BY CROPS IN POUNDS PER ACRE

| | Phosphoric Acid | Nitrogen | Potash | Valuation Per Acre |
|---|---|---|---|---|
| Corn, 40 bu. in the corn and cob | 19 | 38 | 13 | $ 9.52 |
| Wheat, 25 bu | 13 | 29 | 8 | 7.06 |
| Oats, 40 bu | 10 | 25 | 7 | 6.02 |
| Cotton, 250 lbs. in the lint | 0.1 | 0.8 | 0.7 | .21 |
| Potatoes, Irish, 100 bu | 10 | 20 | 36 | 6.76 |
| Potatoes, sweet, 200 bu | 20 | 28 | 72 | 11.12 |
| Alfalfa, 4 tons | 50 | 183* | 143 | 48.18 |
| Sorghum, 3 tons | 29 | 84 | 134 | 26.58 |
| Sugar cane, 20 tons | 15 | 153 | 44 | 34.14 |
| Onions, 30,000 lbs | 27 | 72 | 60 | 20.93 |
| Rice, 1,900 lbs | 12 | 23 | 5 | 5.62 |

*A part of this nitrogen comes from the air.

The table also shows the valuation of the plant food in the crops at the valuation used in Texas during 1913-1914 for commercial fertilizers. The cost per pound of plant food is placed at 20 cents for nitrogen, and 6 cents for potash and phosphoric acid. Furthermore, the above figures apply only to the unmixed fertilizers; the cost in mixed fertilizers is greater, owing to the cost of mixing, sacking, handling, and manufacturer's and dealer's profit. Considering, further, that the plant food applied in a fertilizer is never completely appropriated by the plant, we find that the valuation of the plant food in the crop is below what it would cost in commercial fertilizers.

In addition to the loss of the plant food in the crop naturally removed, there is a loss in the by-products. This loss is largely avoidable. The amounts of plant food in by-products of crops of the size specified are shown in Table 2. The value is also given showing what this plant food would cost if bought in commercial fertilizer materials.

PLANT FOOD IN BY-PRODUCTS OF CROPS IN POUNDS PER ACRE

| | Phosphoric Acid. | Nitrogen | Potash | Valuation Per Acre |
|---|---|---|---|---|
| Cotton (seed, 500 lbs.) | 7 | 16 | 8 | $ 4.10 |
| Cotton (stalk and leaves) | 12 | 32 | 23 | 8.50 |
| Corn, (stalk and leaves) | 6 | 22 | 29 | 6.50 |
| Wheat (straw) | 5 | 13 | 14 | 3.74 |
| Oats (straw) | 4 | 10 | 21 | 3.50 |
| Rice (2,250 lbs. straw) | 3 | 14 | 37 | 3.20 |

The by-products from the farm should, therefore, be utilized as much as possible. The man who sells his cotton seed may have to buy back the plant food he is selling, and pay a good deal more for it than he received for his seed. The rice farmer who wastes his rice straw ashes is losing about 37 pounds of potash per acre, which he will be obliged to buy back some day. The rice farmer loses about $2.70 worth of nitrogen per acre when he burns his straw. Cotton stalks, when burned, lose their nitrogen. The loss of nitrogen may have the value of $3.00 per acre. Therefore, the loss of plant food involved in wasting the by-products of the farm may be considerable, and should be avoided as much as possible.

Winter rains may wash out fertility from a porous sandy soil when it is bare. The loss falls upon the most expensive plant food—the nitrogen. The loss can be avoided by growing a cover crop during the winter, a practice which has been adopted to some extent in East Texas. The sandy soils of East Texas are more likely to lose their fertility in this way than the heavier soils of Central Texas or those of West Texas, where there is less rainfall. It is probable that fertilizer residues are washed out of the soil to a considerable extent from some of the light sandy soils. A winter cover crop is, therefore, recommended for the light sandy soils of East Texas. Mustard has been suggested, and oats are sometimes used; but a leguminous crop, if a suitable one can be found, would be preferable. Burr clover would be excellent for this purpose.

In some sections of the State, unsuitable practices have been followed, with the result that the surface soil has been washed off, leaving the subsoil exposed, usually not fertile. This is, of course, a serious loss, and such methods as prevent it should be followed. Terracing or hill-side ditches, deep plowing or plowing in a proper manner, or other well known methods of preventing washing, should be used.

### SOURCES OF PHOSPHORIC ACID.

Phosphoric acid is applied to the soil in combination, usually in combination with lime, the compounds being known as phosphates of lime. The commercial sources of phosphates are phosphate rock, bone and bone tankage, Thomas phosphate, and guano.

*Phosphate rock* is found in the earth in South Carolina, Florida, Tennessee, Arkansas, and various other places. The phosphoric acid is present as phosphate of lime. There are impurities of various kinds present. The quantity of phosphoric acid in phosphate rock varies from about 25 to 35 per cent.

Phosphate rock, even when finely ground, does not contain its phosphoric acid in such forms that plants can readily take it up. It has been claimed that, when used in connection with stable manure, the phosphoric acid has a much higher value. On account of its low price, ground phosphate rock is used to some extent as a fertilizer in the Middle West. Its action, however, is very slow, even when used in connection with organic matter, and it has practically no effect the first year.

Phosphate rock is usually prepared for fertilizing purposes by treating it with sulphuric acid.

Phosphate rock is the cheapest form in which phosphoric acid may be purchased. If used in connection with manure or organic matter, its use may be profitable on staple farm crops. It cannot be recommended for truck crops.

*Bones*, like phosphate rock, contain phosphate of lime; unlike phosphate rock, bones contain organic matter. Phosphoric acid is more easily taken up by plants from bones than from phosphate rock. This may be partly due to the more porous character of the bones, and partly to the organic matter which is present. Bones are, however, slow in their action, and are best for use on such crops as will occupy the soil for some time.

Bone meal consists of crushed or ground bones. It is slow in its action, and is best used on crops which occupy the soil two years or more—such as grasses, fruit trees, etc. The value of bone meal depends upon its fineness of division and its composition. The finer the bone is ground, the more easily is the phosphoric acid which it contains taken up by plants. Several varieties of bone meal are on the market. Raw bone meal is prepared by grinding raw bones; it contains from 3 to 5 per cent. nitrogen, and from 17 to 20 per cent. of phosphoric acid.

Bones which have been treated with super-heated steam in order to remove the fat and dissolve out the material which forms glue, are ground into steamed bone meal. This material contains less nitrogen and more phosphoric acid than raw bone meal. Phosphoric acid is more easily taken from it by plants, as the bone has been rendered much softer by the steaming. The removal of the fat is also an advantage. Steamed bone meal contains 1.5 to 2.5 per cent. nitrogen, and 22 to 29 per cent phosphoric acid.

Bone tankage is a product of slaughter houses, being composed of the bony residues of animals. It is usually treated with steam in order to remove the fat, which is more valuable than the tankage. The composition of bone tankage is variable. The phosphoric acid present is about equal in value to that in the steamed bone meal. Bone tankage contains more nitrogen than bone meal.

*Thomas phosphate,* also called basic slag, is a product of the manufacture of steel from iron containing much phosphorus. The compound of phosphoric acid in Thomas phosphate contains more lime than that in bone or phosphate rock. Thomas phosphate gives better results on soils which are acid or which contain more organic matter than an ordinary soils. It is little used in Texas.

*Bat guano ash* is rich in phosphoric acid. *Bat guano* contains considerable nitrogen. Bat guano and bat guano ash will be described in connection with nitrogenous fertilizers.

## HOW ACID PHOSPHATE IS MADE.

As previously stated, the phosphoric acid in phosphate rock and bone is taken up very slowly by plants. In order to make the phosphoric acid more easily available, the material is treated with sulphuric acid. The phosphate rock or bone is first finely ground and then mixed with the sulphuric acid. The mixture is dumped upon the floor of the warehouse and allowed to remain there until the reaction is completed. The acid phosphate is then ground up and is ready for use.

We have sometimes received inquiry concerning the preparation of acid phosphate at home. We do not consider it practical for any one to undertake this. The materials must first be ground, and that takes special machinery. The sulphuric acid must be purchased. Sulphuric acid in small quantities is shipped in glass vessels, called carboys, holding about 10 gallons. The freight rate on acid is double first-class. The cost of the acid itself after paying the freight would probably be greater than the cost of the quantity of acid phosphate which could be prepared with its use. Sulphuric acid is also somewhat dangerous to handle; it eats up clothes when it gets on them, chars wood, acts readily upon most materials. We do not advise any one to attempt to prepare acid phosphate from bones or other materials at home. The best way to utilize the bones would be to compost them with manure, or use them for fruit trees.

## FORMS OF PHOSPHORIC ACID IN ACID PHOSPHATE.

The phosphoric acid in acid phosphate is present in three different compounds.

*Water-soluble phosphoric acid* is that which can be extracted from the acid phosphate by means of water. It is combined with less lime than the other compounds of phosphoric acid in acid phosphate. Being soluble in water, it distributes itself in the soil. It is easily taken up by plants and is probably the most valuable form of phosphoric acid Although the water-soluble phosphoric acid combines with some constituents of the soil, and becomes insoluble, this change takes place slowly, and the phosphates formed still have a high value for plants.

*Reverted phosphoric acid* is combined with twice as much lime in proportion to the phosphoric acid present as water-soluble phosphoric acid. Although it is insoluble in water, it can be readily taken up by plants.

Fertilizers containing large proportions of reverted phosphoric acid are prepared from bone and bone tankage instead of from acid phosphate, and are not considered as carrying their phosphoric acid in high-grade forms.

*Available phosphoric acid* is the sum of the water-soluble and reverted. It is the phosphoric acid which can be easily consumed by plants.

*Insoluble phosphoric acid* has three times as much lime in combination with its phosphoric acid as water-soluble. It is the phosphoric acid of the rock or bone which was not acted upon by the sulphuric acid. The phosphoric acid in this form is taken up by plants very slowly. In estimating the value of commercial fertilizers, this form of phosphoric acid is given no value.

## GRADES OF ACID PHOSPHATE.

Three grades of acid phosphate are sold in Texas. That containing 12 per cent. available phosphoric acid is known as 12 per cent. acid phosphate, or acid phosphate 12 per cent. The other grades are 14 per cent. and 16 per cent. and contain 14 and 16 per cent. of available phosphoric acid, respectively. Acid phosphate containing even larger quantities of phosphoric acid are now on the Texas markets.

The purchaser of acid phosphate should examine the tags on the goods carefully, in order to see what grade of goods he is getting. The value of the acid phosphate is, of course, proportional to the quantity of phosphoric acid it contains.

It is usually cheaper to purchase the 16 per cent. acid phosphate. The cost per ton is greater, but the ton contains a large quantity of phosphoric acid, so that the cost of the *plant food* is less than in less concentrated fertilizers. The differences in selling price between 14 and 16 per cent. acid phosphate is often only $1.00 a ton. That is to say, 40 pounds phosphoric acid is secured for the $1.00, so it costs 2½ cents a pound. As the 14 per cent. acid phosphate costs at the rate of 6 cents per pound or more for the phosphoric acid, it is easily seen that the 16 per cent. is cheaper.

## MATERIALS WHICH ARE SOURCES OF NITROGEN.

Like phosphoric acid, different forms of nitrogen have different values to the plant. Some of them are readily taken up by plants, while others are taken up so much slower as to have little or no value.

The chief forms of nitrogen used in mixed fertilizers in Texas are nitrate of soda, cottonseed meal, dried blood, tankage, and bat guano.

*Nitrate of soda* comes from Chili, where it is found mixed with earth. It is removed by extracting the earth with water. After separation and purification, it is put on the market, and contains 95 to 97 per cent. nitrate of soda. It contains 14 to 15 per cent. nitrogen. Nitrate of soda may be used to replace cottonseed meal in any formula given in this bulletin, using one-half as much nitrate of soda. This will change the percentage composition of the fertilizer, making it more concentrated, but smaller amounts may be used to compensate.

Nitrate of soda can be taken up by plants as soon as the roots can come in contact with it. It is therefore, very quick in its action. Nitrate of soda is very easily soluble in water and distributes itself through the soil. But it is easily washed from the soil. Heavy rains may cause losses of nitrate of soda. Losses of this kind are more liable to occur with light sandy soils, such as are used for truck growing, than with heavy soils.

On account of the danger of losing it by washing, and since it is all in condition to be taken up by plants as soon as it reaches the roots, the most economical use of nitrate of soda is to apply it at such times as it is needed and in such quantities as will be completely used. It is profitable upon crops which grow during the winter or early spring, when the bacteria which prepare nitrogenous plant food in the soil are not very active. Nitrate of soda is also of advantage in the production of early truck, or crops in which strong and vigorous early growth is desired. It is thus used for early tomatoes, beets, cabbage, celery, and other market garden crops. It is often profitably used as a top dressing for oats in the spring. It has been recommended for cotton at the rate of 100 pounds per acre, applied just before planting.

As nitrate of soda is best applied when it is needed, the entire quantity should not be placed in the ground when the crop is planted but should be applied as a top dressing when the plants are up. Two or more applications are often advisable and are more likely to give better results than a single large application. The nitrate of soda should not come in direct contact with the plants or be placed too close to them, for it may kill the plant, if the roots come in contact with a strong solution of it. If used as a top dressing, it should be applied after the dew has dried off and scattered thinly. Nitrate of soda is also used in connection with less quickly available nitrogenous fertilizers. It gives the plant an early start, and the other nitrogen feeds the plant later on. It should not be applied to crops planted broadcast when the leaves are wet. Nitrate of soda should not be used for rice.

*Sulphate of ammonia* is a by-product of the manufacture of gas from coal; it contains about 20 per cent. nitrogen. It is easily soluble in water; but the ammonia is fixed and held by the soil so that it does not wash out, as is the case with nitrate of soda. Sulphate of ammonia is a good fertilizer. Sulphate of ammonia is a good form of nitrogen to use on rice.

*Organic Materials.*—Cottonseed meal, bat guano, and similar substances, are termed organic nitrogenous fertilizers. They contain nitrogen in combination with carbon, hydrogen, oxygen, and perhaps other elements. Before organic fertilizers can be taken up by plants, they must undergo change in the soil so that the nitrogen is converted into ammonia or nitrates. The nitrogen stored in the soil is also present in organic forms and must also be converted into ammonia and nitrates, if it is to be useful to plants. This change is brought about by the activity of living organisms, called bacteria. The rate of their action depends upon the nature of the soil, temperature, moisture content of the soil, and other conditions. They are much more active in the summer than in the winter or early spring. It is thus seen that the soil may contain a good store of nitrogen, but if the bacteria do not prepare it for the use of the plants in sufficient quantity, the plants will suffer. If the bacteria are too active, the excess of nitrates may be washed from the soil and lost.

Materials which are quickly changed into ammonia or nitrates in the soil have a high value and are termed readily available.

*Cottonseed meal* is somewhat variable in composition. It contains on an average 7 per cent. nitrogen, 2.5 per cent. phosphoric acid, and 1.5 per cent. potash. It is seen that cottonseed meal thus contains appreciable quantities of phosphoric acid and potash in addition to nitrogen. The nitrogen of cottonseed meal has a high fertilizing value. Cottonseed meal must contain at least 6.88 per cent. nitrogen. If it contains less than this, it may not be sold under the name of cottonseed meal in Texas.

Meal unfit for feeding, which has been made from overheated seed, or which has been cooked too much in the process of manufacture, usually contains as much plant food, and is equally as valuable for fertilizing purposes, as choice meal, provided that it does not contain an excess of hulls. The more hulls present in the meal, the less is its fertilizing (and feeding) value.

The following table shows the fertilizing constituents of Texas cottonseed meal.

*Pounds of Plant Food in 100 Pounds of Cottonseed Meal.*

| | Nitrogen | Phosphoric Acid (Total) | Potash |
|---|---|---|---|
| Average of 321 Texas samples (Bulletin No. 90) | 7.53 | ..... | ..... |
| Average of 21 Texas samples | | ..... | 1.83 |
| Average of 30 Texas samples | | 2.63 | ..... |
| Average of 204 analyses, all States | 6.79 | 2.88 | 1.77 |

*Pounds of Phosphoric Acid in 100 Pounds Cottonseed Meal.*

| | Total | Insoluble | Water-Soluble |
|---|---|---|---|
| Average of 6 | 2.34 | 0.42 | 1.20 |

Cottonseed has nearly half the fertilizing value of cottonseed meal, but the ingredients are in different proportions. The average composition is as follows:

| | |
|---|---|
| Nitrogen | 3.13 per cent. |
| Phosphoric acid | 1.27 per cent |
| Potash | 1.17 per cent |

Cottonseed meal may be replaced, if desired, by two and one-third as much cottonseed, in any formula given in this bulletin. This substitution will, of course, change the percentage composition of the fertilizer, but the quantities of plant food will be in nearly the same proportions, and a larger amount of fertilizer can be applied to the soil to compensate for the smaller percentages of plant food.

*Tankage* consists of refuse materials from slaughter houses, such as blood, scraps of meat and hides, intestines and their contents, bones, etc. It is very variable in composition. It contains some phosphoric acid in addition to its content of nitrogen. Tankage is a valuable fertilizer but not as valuable as dried blood or cottonseed meal. It contains 5 to 10 per cent. nitrogen, and 6 to 15 per cent. of phosphoric acid.

*Dried blood* is obtained by drying the blood from slaughter houses. Its composition is not uniform. It contains 11 to 14 per cent. nitrogen. It is readily transformed into ammonia and nitrates in the soil, and has a high fertilizer value. Very little dried blood is sold in Texas.

*Bat guano* is the dried excrement of bats. It is found in certain caves in Texas, a few of which are now full of bats engaged in the production of this valuable manure. It is a very light material. Pure bat guano is rich in nitrogen and low in phosphoric acid. Bat guano sometimes takes fire through spontaneous decomposition, leaving bat guano ashes.

*Bat guano ashes* are rich in phosphoric acid, but do not contain nitrogen unless mixed with bat guano, as is often the case.

The earth from bat guano caves is sometimes taken to be bat guano. It may contain a small quantity of nitrogen, but it is of a very inferior value as compared with bat guano. Bat guano appears to be a fertilizer of good value. The composition of some samples of so-called bat guano is shown in the following table. On account of the variable compositon of materials supposed to be bat guano, it should only be sold on analysis.

*Composition of Supposed Bat Guano.*

| | Phosphoric Acid Per Cent. | Nitrogen Per Cent. |
|---|---|---|
| I | .92 | 3.93 |
| II | 7.70 | 6.28 |
| III | 5.00 | 9.94 |
| IV | 6.07 | 5.38 |
| V | 4.10 | 10.06 |
| VI | 5.08 | 1.66 |
| VII | 3.97 | 6.49 |
| VIII | 2.97 | 11.55 |
| IX | 4.12 | 11.44 |
| X | 2.02 | 8.67 |

Numbers III, V, VIII, and IX represent high-grade bat guano. No. I is probably a cave earth. Some of the other samples appear to be mixtures of bat guano and bat guano ash.

Hair, wool waste, horn meal, and leather contains high percentages of nitrogen, but they have little value as nitrogenous fertilizers on account of the slowness with which they change in the soil. The use of these materials in commercial fertilizers is prohibited in Texas, because they decay so slowly as to have little value for plants.

*Cyanamid* is prepared by passing nitrogen, obtained from the air, over a mixture of lime and coke, previously fused at a high temperature to form calcium carbide. The calcium carbide takes up nitrogen and forms calcium cyanamid. Cyanamid contains from 15 to 17 per cent. nitrogen, and is used to some extent as a constituent of mixed fertilizers sold in Texas. It contains about 27 per cent. of calcium hydroxide (slacked lime).

Cyanamid is not a good fertilizer for use alone on acid soils or on poor sandy soils of low acidity. If an excessive quantity is applied on such soils at the time of putting in the seed, it may cause injury. It will decrease the available phosphoric acid if the proportion in mixed fertilizers exceeds from 70 to 100 pounds cyanamid to 1000 pounds of acid phosphate. On account of its lime content, cyanamid has a favorable action upon the physical character of fertilizer with which it is used. The quantity of nitrogen in the form of calcium cyanamid in mixed fertilizers should not exceed one-third of the total nitrogen, or furnish more than one and one-half pounds nitrogen in 100 pounds of the fertilizer.

## SOURCES OF POTASH.

Most of the potash used in fertilizers comes from Germany. Immense deposits of potash salts have been found near Stassfurt. The crude salts are mined and subjected to more or less purification, according to the grade of potash salts desired, and then placed on the market. The chief potash salts used in this country are kainit, muriate of potash, and sulphate of potash.

*Kainit* is a term applied to potash salts containing not less than 12 per cent. of potash. Kainit is prepared by mixing crude salts of potash in proportion to secure the desired content of potash, although the term really belongs to a mineral containing sulphate of potash, sulphate of magnesia, and chloride of magnesia. Since kainit is prepared from crude salts, no expense of concentration is attached to it. Since, however, 100 pounds of kainit contains 12 pounds of potash, but 100 pounds of concentrated potash salts contain about 50 pounds of potash, freight charges on potash in kainit are about four times as much as in concentrated salts. At a distance from the mines, the freight charges are greater than the cost of manufacture, so that the potash costs less per pound in the concentrated salts. This is the case in Texas.

*Muriate of potash* contains from 45 to 55 per cent. of potash.

*Sulphate of potash* contains from 45 to 55 per cent. of potash in the form of sulphate. It is somewhat more expensive than muriate of potash but is better adapted to some crops. The chloride in kainit, or in muriate of potash, is injurious to tobacco, as it impairs its burning quality and makes it liable to be damp. It also injures the quality of potatoes, making them less crisp and starchy. For this reason sulphate of potash is preferred to muriate of potash for tobacco, potatoes, and some other crops.

The different forms of potash in fertilizers are all soluble in water, and, therefore, do not differ in availability, although there may be some differences in their effects on account of the other materials which they contain.

*Rice straw ashes* contain about 12 per cent. potash, if they have not been exposed to rain. They thus have about the same value as kainit.

*Rice hull ashes* contain little plant food and have little value.

*Tobacco stems* contain from 6 to 8 per cent. of potash, from 1.5 to 2.5 per cent. nitrogen and from 0.3 to 0.5 per cent. phosphoric acid. They may sometimes be secured at a sufficiently low price to warrant their use as a fertilizer.

*Wood ashes,* if they have not been exposed to the rain, and thereby leached, contain 4 to 9 per cent. of potash and 1 to 2 per cent. phosphoric acid. Wood ashes are very variable in composition, and should be sold by an analysis made of each shipment. The ashes of hard woods contain more potash and are more valuable than those from soft woods. Ashes also contain lime, which will correct the acidity of the soil if the soil is acid.

Ashes which have been leached by exposure to the weather contain 1 to 1.5 per cent. phosphoric acid and about the same quantity of potash. The potash in ashes is very easily soluble in water, and taken out by rain.

Cottonseed-hull ashes are rich in potash, although they vary greatly in composition on account of the other fuel used together with them. Cottonseed-hull ashes may contain 7 to 44 per cent. potash and 2 to 15 per cent. phosphoric acid. On an average, they contain 23.4 per cent. potash, 9.1 per cent. phosphoric acid, and 8.9 per cent. lime.

## FARM MANURE.

There are two ways in which plant food may be purchased; in fertilizers and in feeding stuffs.

Feeding stuffs contain plant food. After they are used by the animal, most of the plant food is excreted by the animal in the solid and the liquid excrement. A small portion is retained by growing animals, and a portion is used by cows in the elaboration of their milk, but the largest part is excreted. The plant food in the excrement is equally as valuable as that in the food, pound for pound. The farmer who feeds cottonseed meal and wastes the manure, gets only the feeding value of his feed. One who buys cottonseed meal for use as a fertilizer gets only its fertilizing value. But one who feeds the meal and saves the manure secures both the feeding value and a portion of the fertilizing value of the feed. How much of the fertilizing value he may secure depends upon the success with which loss is prevented, but since cottonseed meal has a fertilizing value of about $31 per ton, one who feeds meal and saves the manure should get at least $15 a ton more value from his meal than one who uses the meal for fertilizing purposes only, or who feeds the meal and wastes the manure. The greatest manurial value is secured when the animal is fed on the land to be manured. If the liquid manure is not saved, a large part of the value of the manure is lost.

The following table shows the content of plant food in some feeding stuffs used in Texas, and their fertilizing valuation per ton calculated with nitrogen at 20 cents and potash and phosphoric acid each at 6 cents a pound:

*Plant Food in Pounds Per Ton of the Feeding Stuff Named.*

| Name of Feed | Phosphoric Acid | Nitrogen | Potash | Valuation Per Ton |
|---|---|---|---|---|
| Cotton seed meal | 59 | 138 | 30 | $31.40 |
| Cotton seed | 26 | 62 | 24 | 15.40 |
| Corn chops | 12 | 33 | 7 | 7.74 |
| Wheat bran | 54 | 49 | 28 | 14.72 |
| Wheat shorts | 27 | 54 | 12 | 13.14 |
| Rice bran | 40 | 35 | 5 | 9.70 |
| Rice polish | 40 | 37 | 14 | 10.64 |
| Milo maize grain | 8 | 35 | 12 | 8.20 |
| Kaffir corn grain | 12 | 34 | 10 | 8.12 |
| Alfalfa hay | 12 | 46 | 42 | 12.44 |
| Clover hay | 11 | 40 | 36 | 10.82 |
| Meadow hay | 8 | 20 | 26 | 6.04 |
| Corn stover | 6 | 12 | 28 | 4.44 |
| Forney hay | 5 | 22 | 26 | 5.26 |
| Johnson grass hay | 10 | 22 | 46 | 7.76 |

With the exception of cottonseed meal, the above are average analyses from various parts of the United States.

A considerable part of the fertilizing value of the feeding stuff goes into the liquid excrement; in many cases over 50 per cent. (See Bulletin No. 104.)

Manure not only contains plant food, but it supplies the soil with organic matter, which is very necessary to enable the soil to maintain a good condition. Manure is very lasting and durable in its effects.

The following is the average composition of mixed stable manure:

*Pounds of Plant Food in 100 Pounds of Manure.*

| | |
|---|---|
| Phosphoric acid | 0.4 pounds |
| Nitrogen | 0.6 pounds |
| Potash | 0.6 pounds |

The composition of manure is somewhat variable. It depends upon the kind and quantity of food fed, the kind of animal and the nature of absorbents used. It also depends upon the treatment to which it has been subjected. Manure which is piled up loosely and allowed to overheat loses a considerable portion of its fertilizing value. A considerable amount of plant food is washed out of manure exposed to rain.

A ton of barnyard manure contains from 4 to 9 pounds phosphoric acid, 9 to 15 pounds nitrogen, and 9 to 15 pounds potash. It, therefore, contains comparatively small amounts of plant food as compared with commercial fertilizers. Large applications of the manure must, therefore, be made in order to carry much plant food.

Manure has a great indirect action upon the soil; it adds a large amount of organic matter, which increases the power of the soil to hold water. It makes heavy clay soils more open and porous, and on such soils it should be applied in the fresh condition. On light sandy soils it is best applied in the well rotted condition.

In the dry sections of this State, the manure should be well rotted and should not be allowed to dry out before it is plowed under. If it becomes too dry, it may be slow in taking up water and may have the effect of drying out the plowed surface of the soil. In drying out, manure loses a part of its nitrogen which goes off in the form of ammonia.

### HOW COMMERCIAL FERTILIZERS ARE PREPARED.

Commercial mixed fertilizers are prepared by mixing together acid phosphate, nitrogenous materials, and potash salts, in the proportions necessary for the composition desired. In some fertilizers, the phosphoric acid comes partly from bone or tankage. These fertilizers contain only a small proportion of their available phosphoric acid in the water-soluble form and they contain a considerable quantity of insoluble phosphoric acid. Fertilizers made with acid phosphate alone contain two-thirds or more of their phosphoric acid in the water-soluble form and only about one-sixth of the total quantity present is insoluble. Acid phosphate is considered a more desirable source of phosphoric acid in mixed fertilizers than bones or tankage.

After the proper materials have been weighed out, they are mixed thoroughly and passed through a coarse sieve to insure a uniform degree of fineness. Any other material which does not pass through the sieve is ground up and added to the mixture. Sometimes the ingredients must be ground up before they can be mixed, as they may have become hard and lumpy.

### HOME MIXTURES.

By home-mixed fertilizers, we mean the purchase of ingredients and mixing them on the farm in proportions to form the complete fertilizer desired. It would hardly pay to grind bones or other hard materials on a small scale. We have already given reasons why the preparation of acid phosphate from phosphate rock or bones should not be attempted at home. In the home mixing of fertilizers, we simply mix the ingredients which have been purchased for that purpose.

The operation is very simple, the apparatus required being a clean floor, one or two shovels, a pair of scales, and a sand sieve with meshes of about four to the inch. The materials are first weighed out one by one and piled on the floor, any large lumps being broken down with the shovel. The pile is then shoveled over several times, and the mixture passed through the sieve. Any lumps which fail to pass through the sieve are broken up and added to the mixture. The mixture is again shoveled over several times until thoroughly mixed. It is possible to prepare the mixture without using a sieve, but better results are secured with it.

Samples of mixed fertilizers prepared at home have been collected by various experiment stations and examined as to their mechanical condition and chemical composition. The mechanical condition, as a general rule, has been found to be good. The chemical composition did not vary any more from the composition calculated from the ingredients used than mixtures sold by manufacturers vary from their guaranteed analysis.

The New Jersey Experiment Station says that it amply demonstrated in 1893, and corroborated in 1894, that farmers with their ordinary farm appliances can prepare mixtures that compare very favorably with purchased mixtures both in mechanical condition and chemical composition. The Vermont and Maine Experiment Stations made similar statements. Although sometimes materials may become hard and lumpy and give a good deal of trouble in preparing a suitable mixture, it has been found, as a general rule, that farmers can mix their own fertilizers with good results.

Whether or not it is profitable to prepare home mixtures of fertilizers depends upon conditions. The question can be answered by any one who desires, by calculating the cost of the unmixed materials, and, after allowing for the cost of mixing, comparing the results with the prices at which the mixed fertilizers can be purchased. The quantity of each ingredient to be used in making the mixture must, of course, be known, and the cost of the ingredients, including freight charges, must also be ascertained.

At this experiment station the cost of ingredients for six fertilizers was compared with the selling price of the mixed fertilizers, using the retail cash price of the ingredients, and of the mixtures as actually found on the market. Some of the mixed fertilizers sold for about the same price as the cost of the ingredients. On an average the retail price of the ingredients for the six fertilizers was $3.38 per ton less than the selling price of the corresponding mixed fertilizers. If the wholesale cost of the ingredients had been used, the difference, of course, would have been greater, but it is not fair to compare wholesale or carload prices of ingredients with retail or ton prices of mixtures. It is also not fair to compare the cash cost of home mixtures with the credit prices of complete mixtures.

Whether or not home mixing will pay must be decided in each individual case.

The manufacturer has the advantage of purchasing his materials in large quantities at wholesale prices. He also has the advantage of possessing the necessary machinery and appliances for mixing at a lower cost per ton than the home mixer. In some cases the mixed fertilizers can be purchased cheaper from the manufacturer in carload lots than the mixed fertilizers can be prepared at home. In other cases, however, it will be more economical to make the home mixture. Many farmers have found it profitable to prepare their own mixtures, and most experiment stations advocate it.

It may be said further in favor of home mixtures that the grade of materials used is known. It is also easy to vary the mixture for the purpose of testing the effect of different combinations upon the soil.

## FORMULAS FOR MIXTURES.

### I.

| | |
|---|---|
| Acid phosphate, 16 per cent. | 1,200 pounds |
| Cottonseed meal, 6.88 per cent. | 800 pounds |
| Total | 2,000 pounds |

This mixture contains approximately 10 per cent. available phosphoric acid and 2.7 per cent. nitrogen.

II.

| | |
|---|---|
| Acid phosphate, 16 per cent | 1,000 pounds |
| Cottonseed meal, 6.88 per cent | 1,000 pounds |
| Total | 2,000 pounds |

This mixture contains approximately 9 per cent. available phosphoric acid and 3.45 per cent. nitrogen.

III.

| | |
|---|---|
| Acid phosphate, 16 per cent | 800 pounds |
| Cottonseed meal, 6.88 per cent | 1,200 pounds |
| Total | 2,000 pounds |

This mixture contains approximately 7.6 per cent. available phosphoric acid and 4.13 per cent. nitrogen.

IV.

| | |
|---|---|
| Acid phosphate, 16 per cent | 666 pounds |
| Cottonseed meal, 6.88 per cent | 1,334 pounds |
| Total | 2,000 pounds |

This mixture contains approximately 6.6 per cent. available phosphoric acid and 4.58 per cent. nitrogen.

V.

| | |
|---|---|
| Acid phosphate, 16 per cent | 1,200 pounds |
| Cottonseed meal, 6.88 per cent | 600 pounds |
| Nitrate of soda, 14.88 per cent | 200 pounds |
| Total | 2,000 pounds |

This mixture contains approximately 10 per cent. available phosphoric acid and 3.5 per cent. nitrogen.

VI.

| | |
|---|---|
| Acid phosphate, 16 per cent | 1,080 pounds |
| Cottonseed meal, 6.88 per cent | 800 pounds |
| Muriate of potash, 50 per cent | 120 pounds |
| Total | 2,000 pounds |

This mixture contains approximately 8.5 per cent. available phosphoric acid, 2.7 per cent. nitrogen and 3.0 per cent. potash.

VII.

| | |
|---|---|
| Acid phosphate, 16 per cent | 840 pounds |
| Cottonseed meal, 6.88 per cent | 1,000 pounds |
| Muriate of potash | 160 pounds |
| Total | 2,000 pounds |

This mixture contains approximately 7.0 per cent. available phosphoric acid, 3.45 per cent. nitrogen and 4.0 per cent potash.

VIII.

| | |
|---|---|
| Acid phosphate, 16 per cent | 800 pounds |
| Cottonseed meal, 6.88 per cent | 800 pounds |
| Nitrate of soda, 14.88 per cent | 200 pounds |
| Muriate of potash, 50 per cent | 200 pounds |
| Total | 2,000 pounds |

This fertilizer contains approximately 6.8 per cent. available phosphoric acid, 4.2 per cent. nitrogen and 5.0 per cent. potash.

If any other formulas besides those mentioned above are desired, they can be secured on application to the Chemist of the Experiment Station, College Station, Texas.

### HOW TO CALCULATE THE INGREDIENTS TO BE USED FOR MIXED FERTILIZERS.

It is not a difficult matter to calculate how much of the various ingredients should be used to make a mixed fertilizer. Suppose it is desired to make a fertilizer containing 8 per cent. phosphoric acid, 1.65 per cent. nitrogen, and 2 per cent. potash, using acid phosphate guaranteed to contain 14 per cent. available phosphoric acid, kainit containing 12 per cent. potash and cottonseed meal containing 7 per cent. nitrogen, 2 per cent. available phosphoric acid and 1.5 per cent. potash.

A fertilizer containing 8 per cent. phosphoric acid contains 8 pounds in 100 pounds or $8 \times 20 = 160$ pounds available phosphoric acid in a ton. The amount of nitrogen in this fertilizer would be $16.5 \times 2 = 33$ pounds per ton and the potash $2 \times 20 = 40$ pounds per ton.

Since cottonseed meal contains all three kinds of plant food, but is used chiefly for its nitrogen, we will begin the calculation with cottonseed meal and nitrogen. One hundred pounds of cottonseed meal often contains 7 pounds of nitrogen, so 1 pound contains .07 pounds. To find out how many pounds of cottonseed meal must be used to get the 33 pounds of nitrogen desired in our fertilizer, we divide 33 by .07, which gives 471 pounds. This quantity of cottonseed meal contains $471 \times .02 = 9.4$ pounds phosphoric acid and $471 \times .015 = 7.1$ pounds of potash.

Since 160 pounds of available phosphoric acid must be present in a ton of fertilizer and the cottonseed meal contains 9.4 pounds, we need to secure 150.6 pounds of phosphoric acid from the acid phosphate. The 14 per cent. acid phosphate contains .14 pounds available phosphoric acid in 1 pound. We divide 150.6 by .14, which gives us 1076 pounds acid phosphate. This quantity of acid phosphate contains 150.6 pounds available phosphoric acid.

The ton of fertilizer must contain 40 pounds of potash, of which 7 pounds has been furnished by the cottonseed meal, which we need to supply the nitrogen, leaving 33 pounds to come from kainit. Since 1 pound of kainit contains 0.12 pounds of potash, 33 pounds will be contained in 33 divided by .12=275 pounds of kainit.

A ton of this fertilizer would then be composed of the following ingredients:

| | |
|---|---|
| Cottonseed meal | 471 pounds |
| Acid phosphate | 1,076 pounds |
| Kainit | 275 pounds |
| Filler | 1,817 pounds |
| Total | 2,000 pounds |

In order to get the exact composition, 178 pounds of some indifferent material must be used as a filler.

The above illustration shows how the ingredients to make any desired fertilizer can be calculated exactly from a knowledge of the composition of the ingredients to be used. In practice, however, it is necessary to use somewhat more than the calculated ingredients in order to allow for variations in the material and also on account of the change in potash. In making a mixed fertilizer containing potash, a small amount of potash usually becomes fixed so that it does not appear as water-soluble potash in the analysis.

### DO NOT BUY RECIPES FOR MAKING FERTILIZERS.

From time to time parties go around selling formulas for fertilizers, which they claim to be "secret" or "wonderful discoveries." Most of the recipes that have been sold in this way are worthless. Mixtures prepared according to the directions given are not worth the time and labor applied to them. Ingredients are called for which can only be purchased at high prices and likely as not are wholly without value to the plant or the soil.

The following is an example of a fertilizer recipe which has been offered for sale in this State:

| | |
|---|---|
| Bluestone | 2 pounds |
| Saltpeter | 2 pounds |
| Nitrate of ammonia | 2 pounds |
| Soda ash | 2 pounds |
| Potash ball | 4 pounds |

"Dissolve in five gallons of water and sprinkle on the sand; make a ton sufficient for one acre."

Not a single one of the substances mentioned is used in making fertilizers. Bluestone and soda ash do not contain any plant food. Saltpeter, ammonium nitrate, and potash contain potash and nitrogen, but they are too expensive to be used as a fertilizer. The potash would act upon the ammonium nitrate and drive off the ammonia, making the mixture smell like ammonia. The smell would not grow any plants. The mixture would contain about 3 pounds of potash, and 1 pound of nitrogen and would have a fertilizer valuation of 33 cents per ton, but the purchased ingredients would cost from $1.50 to $2.00.

The Experiment Station will furnish without charge formulas for preparing fertilizers. The expenditure of money in purchasing them is useless.

### PURCHASE FERTILIZERS FOR THE QUANTITY OF PLANT FOOD IN THEM.

There are two ways of buying fertilizers; one is to pay so much per ton and the other way is to pay so much per pound of plant food. Consumers of fertilizers usually buy on the ton basis. Manufacturers of fertilizers pay so much per pound for the plant food they receive.

Too little attention is paid by consumers of fertilizers to the quantity of plant food in the fertilizer. Our inspectors have sometimes found two grades of acid phosphate on the market, selling exactly for the same price per ton.

If an acid phosphate contains 12 per cent. phosphoric acid, the purchaser of a ton gets 240 pounds of phosphoric acid; if it contains 14 per cent., the purchaser gets 280 pounds of phosphoric acid. If 12 per cent. acid phosphate is worth $1.00 per 100 pounds, the 14 per cent. acid phosphate is worth $1.17 per 100 pounds, or very nearly 20 per cent. more. Thus the consumer who purchases 14 per cent. acid phosphate, when both 12 and 14 per cent. are selling at the same price, secures nearly 20 per cent. more value for his money than he would have secured if he had purchased 12 per cent. goods. The time should soon come when it would be impossible for two grades of acid phosphate to sell for the same price in the same town: Sixteen per cent. acid phosphate is usually the cheapest way to buy phosphoric acid.

What has been said in reference to acid phosphate also applies to mixed fertilizers, although in this case the differences are not as plain. The valuation is a measure of the relation between the composition and the selling price. The valuation above should not be considered, but the composition selected should approach as nearly as possible to that desired. The following table shows the composition, valuation, and selling prices of three fertilizers offered for sale at a certain town during the season 1907-08:

| | No. I | No. II. | No. III. |
|---|---|---|---|
| Available phosphoric acid | 10.00 | 9.50 | 8.00 |
| Nitrogen | 1.65 | 1.65 | 1.64 |
| Potash | 2.00 | 1.50 | 2.00 |
| Total plant food in 100 pounds | 13.65 | 12.65 | 11.64 |
| Valuation per ton | $20.01 | $18.81 | $17.58 |
| Selling price | $27.50 | $26.00 | $27.00 |

These fertilizers have very nearly the same composition, the chief difference being in their phosphoric acid content. The purchaser of these fertilizers would secure the following number of pounds of plant food per ton at the price named:

No. I—273 pounds for $27.50.

No. II—253 pounds for $26.

No. III—232 pounds for $27.

The average cost of plant food in fertilizer No. I is 10.1 cents per pound; in No. II it is 10.3 cents; in No. III it is 11.6 cents.

Comparison may also be made by dividing the selling price by the valuation. The cost of one dollar valuation is thus: in No. I, $1.375; in No. 2, $1.38; in No. 3, $1.53. Thus, No. 3 is the most expensive.

This example is sufficient to show that the purchase of commercial fertilizer involves some care and knowledge, if the money is to be expended to the best possible advantage.

### BUY HIGH-GRADE FERTILIZERS.

As a general rule, we advise purchasers of acid phosphate to secure 16 per cent. acid phosphate, since the plant food is cheaper in that grade.

We do not *advocate* the use of a mixed fertilizer containing less than 2.5 per cent. nitrogen. If potash is desired at all, we do not *advocate* the use of a mixed fertilizer containing less than 3 per cent. potash.

If the fertilizer contains only nitrogen and phosphoric acid, the nitrogen multiplied by two and added to the phosphoric acid, should not be less than 15.5 for a grade of fertilizer containing little filler. We do not *advocate* the use of fertilizer of lower grade.

If the fertilizer contains only potash and phosphoric acid, the sum of the two should not be less than 14 per cent., and we would prefer it not to be less than 16 per cent.

When a fertilizer contains phosphoric acid, nitrogen and potash, the nitrogen multiplied by two and added to the phosphoric acid and potash, should not be less than sixteen for a grade of fertilizer containing little or no filler. We do not *advocate* the use of fertilizer containing less plant food.

### EFFECT OF KEEPING ON COMPOSITION OF FERTILIZERS.

We have had a number of inquiries in regard to keeping fertilizers. In 1907 we estimated the phosphoric acid in twelve samples of fertilizers, which had been kept for two years in a dry condition in sample bottles. These samples were then placed in pint jars, which were filled about two-thirds full. The jars were left open. The samples were kept in a basement which is at times rather damp. In 1908 these samples were again analyzed. The results are presented in the table below:

AVERAGE COMPOSITION OF TWELVE FERTILIZERS.

| | 1905 | 1907 | 1908 |
|---|---|---|---|
| Water-soluble phosphoric acid | 6.73 | 6.33 | 5.89 |
| Differences (average) | | —.40 | —.44 |
| Insoluble phosphoric acid | 0.94 | 1.02 | 1.10 |
| Differences (average) | | +.08 | +.08 |

It is seen from the table that the average loss of available phosphoric acid was practically equal for the two periods, one of which, however, extended over two years, and the other one year. The loss in water-soluble phosphoric acid is likewise the same for the two periods, but the loss in both cases is very small.

Fertilizers that are kept over should be stored in a dry warehouse, and protected from moisture as much as possible. Under these conditions, there is little or no loss of plant food in fertilizers when carried over from one season to another.

## TEXAS FERTILIZER LAW.

Full information in regard to the Texas Fertilizer Law and the work done under it is published from time to time in the form of bulletins. These bulletins can be secured free of charge, on request.

## HOW TO MAKE EXPERIMENTS WITH FERTILIZERS.

The user of commercial fertilizers should make such applications as he has found by experience to be best adapted to his soil and the crops which he is growing. Methods which he has found good should not be abandoned and new ones tried on a large scale until he has carefully tested the new methods and found them good. There is no doubt that many improvements can be made in the application of fertilizers. The progressive farmer will make tests of different fertilizing mixtures on his soil, even if these tests are confined to a comparison of two different mixed fertilizers. Such experiments will prove profitable when properly conducted.

In making a fertilizer test the soil selected should be uniform, so that the differences in the crop will be due to the difference in the fertilizer and not to differences in the soil. The plot should not be located so that the fertilizing material from one plot may wash over from another. The products from the different plots should be weighed, as only by exact weighings can the exact differences in results secured by the different treatments be known.

The careful work that is done at experiment stations and experiment farms is mainly to ascertain scientific truths, and facts of general bearing, and is of great value and importance. The application in individual cases must depend upon individual knowledge, based on experience and experiments. Not only do the various agricultural crops differ widely in their requirements for plant food, but the various soils of the farm show different needs, and the same kind of soil may vary under different treatment, even from one season to another. Hence every progressive farmer, holding fast to what is good and seeking for what is better, must continuously study his soil and crop, and must himself become an experimenter on a more or less limited scale.

Decisive results are rarely obtained in one season and frequently the experiments are spoiled by unfavorable weather, insects, plant diseases, and other causes; for this reason the experiments should be continued from year to year. Fertilizer experiments are carried on in a variety of ways, from very simple tests in which one material is compared with another, and only two plots are used, to very thorough and complicated experiments, conducted on a uniform plan for a number of years. The Chemist of the Experiment Station will co-operate at any time in the preparation of plans for fertilizer experiments on any desired crop.

### CO-OPERATIVE FERTILIZER EXPERIMENTS.

The following are instructions sent to those co-operating in the fertilizer experiments:

Please read these instructions carefully as soon as you receive them. If there is anything you do not understand, or if you desire further information, write to us fully.

Please advise us whether or not the fertilizer arrives in time and in good condition. If any bag is torn, please weigh it. Please note carefully any changes that may have been made to suit your conditions.

Select a uniform piece of land of about an acre for corn or cotton, and about half an acre for truck crops. This is to be divided into plots. Each plot must naturally produce the same quantity of cotton or corn or other crops. Any natural difference in the productiveness would appear as due to the fertilizer, whereas it is really due to the soil. So take care to select a piece of land which produces the same amount of crop in all its parts, and which does not contain any rich or poor spots, and no portion of which is subjected to more favorable or unfavorable conditions than any other portion.

For corn, cotton or similar crops use an area equivalent to approximately one-tenth acre for each plot or application of fertilizer. If the rows are 4 feet apart, use 4 rows 280 feet long, or 8 rows 140 feet long, or 16 rows 70 feet long.

For potatoes, tomatoes, onions, or similar crops, use an area of land equivalent to one-twentieth acre for each plot or application of fertilizer. If the rows are 4 feet apart, use 2 rows 280 feet long, or 4 rows 140 feet long, or 8 rows 70 feet long. If the rows are 2 feet apart, the number of rows for each application of fertilizer should be double that stated above.

The important point is to have the same number of rows of exactly the same length.

The applications to the different plots are as follows:

Plot No. 1.—Apply nothing.

Plot No. 2.—Apply bag No. 2, 15 pounds acid phosphate.

Plot No. 3.—Apply bag No. 3, 20 pounds cottonseed meal.

Plot No. 4.—Apply 15 pounds acid phosphate, 10 pounds cottonseed meal, 5 pounds nitrate of soda.

Plot No. 5.—Apply bag No. 5, 15 pounds acid phosphate, 20 pounds cottonseed meal.

Plot No. 6.—Apply bag No. 6, 15 pounds acid phosphate, 20 pounds cottonseed meal, 2 pounds sulphate of potash.

Plot No. 7.—Apply bag No. 7, 15 pounds acid phosphate, 20 pounds cottonseed meal, 5 pounds sulphate of potash.

Plot No. 8.—Apply nothing.

Plot No. 9.—Apply one load of manure.

Plot No. 10.—Apply bag No. 10—either (a) 15 pounds Thomas phosphate, or (b) 40 pounds hydrated lime (apply two weeks before planting), or (c) 20 pounds rock phosphate.

The fertilizer should be mixed well and applied in the drill about a week before the seed are planted. It should not be allowed to come in direct contact with the seed. The entire field should receive the same treatment, and if any of the spots are damaged by storms, insects, or anything else, the fact should be noted and considered. The only difference between the plots should be the quantity of fertilizer. The date of maturity should be stated and the crop from each plot should be harvested and weighed separately.

A report blank will be furnished. Report total weight of ear corn per plot, weight of seed cotton per plot, total weight of potatoes per plot, and weight of those marketable, etc. The stand on each plot should also be noted and reported. Note any difference in size of stalk or appearance of plot. You should retain a copy of the report and of your observations for your own use.

This experiment should show which of these fertilizers would prove probably most profitable under your conditions, and it would give you an intelligent basis for fertilizing next season.

Information concerning fertilizers is contained in Bulletins of the Texas Experiment Station; reports of Co-Operative Experiments in Bulletin No. 138. Any bulletin is free on application. Requests for bulletins should be addressed to the Director of the Experiment Station.

We prefer the fertilizer to be applied by hand, distributing it as evenly as possible. A tin or paper horn reaching nearly to the ground may be used if there is much wind. If necessary, the fertilizer may be applied just before planting, but the plow should be run through the furrow to mix it with the soil, or some other method of mixing used. The fertilizer must not come in direct contact with the seed. If the fertilizer does not arrive in time, it may be applied after the seed has been planted, by opening a furrow along the side of the plants, putting in the fertilizer, and dirting back upon it.

We cannot undertake to give cultural directions, on account of the wide diversity of conditions within the State. Each plot should, of course, be treated alike. As a general rule, we would suggest deep fall breaking—five or six inches. Do not, however, increase the depth of breaking suddenly, but break a little deeper than you have been doing. After each rain, cultivate shallow as soon as the land is in condition to work. In the spring, after the seed are planted, cultivate shallow at least once a week. The object of this treatment is to retain the water in the soil. If there is likely to be too much moisture, provision should be made for drainage.

## PRECAUTIONS IN MAKING FERTILIZER EXPERIMENTS.

The following are some precautions that should be observed:

1. The greatest care should be taken to select land which is as uniform as possible in fertility. Lack of uniformity will give misleading results, and often render the experiment of little value.

2. If possible, select level land. If such cannot be had, the plots

should run up and down the slopes, so that rain will not wash fertilizing material from one plot to the other.

3. The experimental plots should be measured off carefully, and each plot indicated by stakes or stones.

4. It is best to have the experimental plots long and narrow; because thus they will average up for unevenness of soil.

5. It is best to separate plots by paths, or an unfertilized row, to prevent roots of plants in one plot from feeding on the fertilizer supplied to adjoining plots.

6. Avoid windy days in applying fertilizer, so that it may not be blown and scattered unevenly over the plots.

7. All the plots must be treated alike in every respect, except as to the amount and kind of fertilizer applied. The same kind and quality of seed must be used over the entire area. The plowing or sowing on all the plots must be done the same day. If part be planted before and part after a rain, the experiment may become valueless. Use every precaution necessary to secure a full stand of plants, and if a good stand has not been secured at the first planting, plow up the whole field and plant over again. Arrange the same number of rows on each plot and the same number of hills and plants, as nearly as possible, in each row. The plots should be plowed and cultivated alike, and whatever operation is needed should be carried out uniformly all over the plots.

8. The harvesting of the crop and weighing of yields must be accurate.

Fertilizer is furnished for cooperative experiments under certain conditions. Those interested should write for information in November or December.

### WHY DIFFERENT SOILS NEED DIFFERENT FERTILIZERS.

Soils differ in their requirements for plant food. Some respond to applications of phosphoric acid, others to nitrogen and others to potash. Sometimes a soil requires two or more kinds of plant food. The reasons that soils differ in their requirements for plant food are as follows:

1. Soils are naturally different in their chemical composition, and in their needs for plant food. As a rule, sandy soils are more likely to need potash than clay soils. They are also more likely to require nitrogen. The material of which clay soils is composed naturally contains more potash than the materials of sandy soils.

2. Soils originally the same may become different through different treatment. One kind of crop may exhaust the soil of one kind of plant food and yet an abundance of the other kind may remain in the soil. The cultivation of different crops in succession instead of the continuous culture of the same crop on the same soil, year after year, is more likely to utilize completely the plant food in the soil.

The needs of certain types of Texas soils have been discussed in Bulletins Nos. 128 and 161 of this Station.

### WHY DIFFERENT CROPS NEED DIFFERENT FERTILIZERS.

Crops differ in their requirements for plant food. Some require considerably more potash or nitrogen or phosphoric acid than others. They also differ in the ability to secure plant food. Some plants grow quickly and must take up their plant food rapidly. They thus require an abundance of easily available plant food. Other plants grow more slowly and take a long time to mature. They can utilize the more difficulty available forms of plant food, which would be almost useless to the plants first named.

These differences account for the fact that different plants require different fertilizers even on the same soil.

It is not possible to prepare formulas for fertilizers which are "best" for this or that crop. This is seen by the fact that fertilizers put up for special crops by different manufacturers may vary widely in composition. The best fertilizer to use depends both on the soil and on the kind of crop, thought it is always safe to apply an abundance of plant food, if the crop is valuable. However, this may lead to waste of plant food. Some fertilizer formulas are based on the analyses of plants, but plants vary in their power to secure food, as well as in their needs, and they take up an excess (especially of potash) when they can get it.

### DO FERTILIZERS INJURE SOILS?

We have sometimes been asked whether or not fertilizers injure the soil. We can answer this question by saying that if properly used they will not injure the soil, but are essential to any plan for permanently maintaining soil fertility.

There are, indeed, cases in which, apparently, the fertilizer has been injurious. A farmer, for example, finds that the application of 200 pounds per acre of acid phosphate will increase his crop of cotton considerably. He make this application for three or four years, then finds that his cotton crop is smaller than it was to start with, or he discontinues the application of fertilizers and does not get much of a crop. Apparently, the acid phosphate had injured the soil.

The injury has, however, been caused by the method of farming and not by the fertilizer. The acid phosphate supplied only phosphoric acid to the soil. The increased crop has increased the demand for nitrogen and potash, so that the quantity in the soil has diminished until it is no longer the phosphoric acid but the nitrogen or potash which controls the yield of the crop. The one-sided application of plant food has aided in the exhaustion of the soil in the other plant foods. The other plant foods can, of course, be restored by using fertilizers containing them, or, in the case of nitrogen, by a proper crop rotation.

The continuous cultivation of cotton has also decreased the organic matter in the soil, impaired its physical condition, and rendered it less suitable for the growth of cotton. This, however, is not due to the application of the fertilizer, but to the continuous cultivation of cotton. The remedy is to abandon the continuous cultivation of cotton and substitute a rotation of crops in which cotton may be followed by cowpeas or some other leguminous crop.

### APPLICATION OF FERTILIZERS.

Crops may be divided into two classes with reference to the application of fertilizers.

The first class includes those crops which have a comparatively low value per acre and to which large applications of fertilizer cannot be made without costing a considerable proportion of the value of the crop. For these crops the plant food in the soil must be utilized as fully as possible, and the application of fertilizer must be made as skillfully as possible. The cropping system should be arranged so as to utilize economically the residues from the previous application.

As a general rule, it may be said that it is not profitable to purchase all the nitrogen needed by crops of this character. The fertility of the soil must be maintained with nitrogen secured from the air, and nitrogenous fertilizers should be used only to supplement the supply secured in this way. This involves a rotation of crops, in which nitrogen-gathering plants are grown—cowpeas, vetch, burr clover, peanuts, etc. Cheap phosphates of low availability may be used on crops of this character.

The second class of crops includes those which have a high value per acre and for which even large applications of fertilizers may cost only a comparatively small proportion of the value of the crop. These crops, as a general rule, must be grown as rapidly as possible, and they require abundant supplies of plant food. Although attention should be paid to the needs of the soil, it is possible to make such heavy applications of plant food that the supply in the soil may be more or less disregarded. These crops can, of course, be followed by other crops to utilize the large residues of plant food. These crops should also be grown in rotation with other crops, and provision should be made for maintaining the store of vegetable matter in the soil.

It is not possible to make a strict classification of crops under these groups, for conditions which place a crop in one group in one locality may place it in another group in another locality. A high price for a crop, due to market conditions, may change it from the first to second group. Cotton, corn, rice, and alfalfa can be classed with crops of low acre value, and onions, sweet potatoes, tomatoes, melons, asparagus and similar crops with those of high acre value.

The suggestions given in the following paragraphs in regard to fertilizers for various crops should not be taken as rules to be followed, but as suggestions to be tried. Soils and conditions vary, and the best fertilizer should be ascertained by the experience and experiments of those concerned.

## METHODS OF APPLICATION.

Moderate applications of fertilizers are best made at the time of planting, or a week or so before. The fertilizer should not be allowed to touch the seed, as it might interfere with germination. Small quantities are best applied in the row or furrow, to plants grown in rows; large quantities may be applied broadcast, but, in any event, they should be mixed well with the soil.

Fertilizer drills may be purchased through dealers in agricultural implements. Several kinds are on the market. Implements may be secured which plant the seed and apply the fertilizer at one operation; that is to say, they are combined planters and fertilizer distributors. Separate fertilizer distributors may also be secured. Those who expect to use considerable quantities of fertilizer will find it profitable to secure implements for applying it.

When heavy applications of fertilizer are to be made, a portion may be applied about the time of planting, and the remainder in one or two subsequent applications. If only one subsequent application is made, it should be made about the time the plants begin to set their fruit. If two applications are made, the first should be made a little earlier. The fertilizer should not be applied to a wet soil. It should not be applied by opening a furrow near the drill rows and putting it in, as this cuts the roots of the plants. It is best to put the fertilizer near the drill rows, just before cultivation, so that the cultivator will mix the fertilizer with the soil.

## FERTILIZERS FOR COTTON.

Fertilizers alone will not maintain the fertility of cotton soils. This may as well be recognized in the beginning by those who are using commercial fertilizers. Commercial fertilizers properly used will maintain soil fertility and aid in building it up. Commercial fertilizers improperly used will result eventually in depleting the soil of its fertility, and causing it serious injury. Commercial fertilizers are properly used in connection with a rotation of crops which includes leguminous crops to be turned under, grazed off, or made into manure. This is for the purpose of supplying nitrogen and vegetable matter to the soil. Used in connection with a rotation of the proper kind, in which a leguminous crop is grown sufficiently often, and in which the manure is saved very carefully if the legume is fed, commercial fertilizer will aid not only in maintaining but in increasing the productiveness of the soil.

Commercial fertilizers may be temporarily used to advantage in the absence of such a rotation, but for permanent fertility or soil building, a rotation is a necessity. On new lands which give a large stalk but are deficient in fruit, acid phosphate may be used alone for two or three years with advantage. The use of the acid phosphate will often result in decreasing the size of the plant and increasing the quantity of cotton produced. There are some soils which are exceptions to this rule, and on which the addition of the acid phosphate does not have this favorable effect. These are usually bottom soils rich in carbonate of lime. The use of acid phosphate in this way must be regarded as a temporary expedient. The cropping will in time decrease both the nitrogen and the vegetable matter in the soil, and these will become the controlling elements rather than the phosphoric acid. When this occurs, a suitable rotation should be introduced as recommended above.

Mixed fertilizers also find a temporary use to advantage when the rotation has not been started on some soils, but this use must also be regarded as temporary and the suitable rotation should be introduced as soon as possible. Our recommendations for fertilizer on cotton soils are as follows:

1. The temporary use of acid phosphate at the rate of 100 to 200 pounds per acre on land which produces a large stalk, which is deficient in fruit.

2. A rotation of crops on all cotton land, in which peas, peanuts,

or some other legume, are grown at least one year in three to be turned under or grazed off. The legume may also be harvested and fed, but the manure must be saved very carefully and returned to the soil. If the legume is taken away and the manure not returned, its use will have little effect in maintaining the soil fertility.

A rotation suitable to many sections of the State consists of:

The first year, corn six feet apart with cowpeas between the rows. In dry sections the cowpeas should be planted the same time as the corn, but in the humid sections the peas may be planted at the time the corn is laid by. In the fall the peas are turned under, grazed off, or made into manure.

Oats are planted next. If they give promise of a crop, they may be allowed to grow to maturity, and then cowpeas are planted again. These are turned under or made into manure, and oats or some other winter cover crop again planted.

The oats or other winter cover crop are turned under, and cotton planted.

In the fall this is succeeded by another cover crop.

The next year the rotation begins again with corn.

The kinds of fertilizers to be used in connection with the rotation mentioned above depend a great deal on the character of the soil and on the size of the crop that it is possible to produce by fertilizer in connection with good tillage, good seed and the ordinary season of the locality.

On some heavy soils, especially on bottom soil, the only fertilzer needed in connection with the rotation or likely to be needed is acid phosphate.

On other heavy lands it would be advisable to use some acid phosphate and nitrogen upon the cotton. Cottonseed meal, sulphate of ammonia or some other nitrogenous fertilizer could be used as a source of nitrogen. A mixture of equal parts of acid phosphate and cottonseed meal would be a good basis to begin with. The proportion of the mixture should then be changed to suit the soil. Soils of this heavy character are well supplied with potash and will need little potash to produce good crops.

On most heavy loams, acid phosphate and cottonseed meal would be sufficient at first, provided the capability of the soil were not beyond a bale of cotton per acre. If it exceeds this quantity, the use of potash would also be advisable.

On light sandy soils it would be advisable to use some potash in the beginning. A fertilizer containing about 8 per cent. phosphoric acid and 2½ per cent. each of nitrogen and potash would be a good fertilizer on such soils. In the absence of a crop rotation, it is advisable to increase the quantity of nitrogen, especially on some sandy types of Texas soil. These soils are very poor in nitrogen and respond well to fertilizers. The use of fertilizer on such land is very profitable, but their most profitable use, as stated, will be in connection with a rotation of crops.

The Georgia Experiment Station recommends the following fertilizer for cotton on old, worn uplands. It will no doubt give good results:

| | |
|---|---|
| Acid phosphate | 1,000 pounds |
| Cottonseed meal | 671 pounds |
| Kainit | 296 pounds |

This fertilizer would contain 8 per cent. phosphoric acid, 2.4 per cent. nitrogen, and 2.4 per cent. potash. It is applied at the rate of 400 to 800 pounds per acre by that station. Eight hundred pounds of this fertilizer will supply about one-half as much nitrogen as is removed in lint and seed of a crop of 300 pounds of lint; it would supply an abundance of potash and phosphoric acid.

3. Before a rotation is established, fertilizers may be used as suggested above, but a proper rotation should be established as soon as possible. In the absence of a rotation, the soil will need more fertilizer nitrogen than with the rotation.

### MAINTAINING THE FERTILITY OF COTTON SOILS.

The soil loses fertility not only in the crop carried off, but also in the water which passes through the soil. This loss falls principally upon nitrogen, the most expensive plant food. If we assume that 15 pounds of nitrogen are lost annually in the drainage waters, the total loss in growing a crop of 300 pounds of lint cotton, when only the lint and seed are removed, may be estimated as follows:

| | |
|---|---|
| Phosphoric acid | 9 pounds per acre |
| Nitrogen | 37 pounds per acre |
| Potash | 9 pounds per acre |

If the stalks are burned, there is a larger loss of nitrogen, and if they are removed before burning, so that the ashes are lost to the field, there is a larger loss of potash. The use of acid phosphate alone can be considered as a temporary method of supplementing the plant food in the soil. The income and outgo of an acre of land planted to cotton and receiving 100 pounds acid phosphate alone is shown in the following table. We assume that the production is 300 pounds lint per acre:

| | Phosphoric Acid | Nitrogen | Potash |
|---|---|---|---|
| Loss when 300 pounds of lint is grown. | 9 lbs. | 37 lbs. | 9 lbs. |
| Income per year from 100 pounds acid phosphate, 16 per cent. | 16 lbs. | ....... | ....... |
| Gain per year | 7 lbs. | ....... | ....... |
| Loss per year | ...... | 37 lbs. | 9 lbs. |

The use of acid phosphate alone depletes the soil of its nitrogen and potash. After a comparatively short time, the need of the soil for nitrogen will be greater than its need for phosphoric acid, and the application of acid phosphate will not give satisfactory results. The remedy is, of course, to supply the plant food which is needed; namely, nitrogen and potash.

The use of an 8-2-2 fertilizer in continuous cotton culture will also in time fail to give satisfactory results. The income and outgo when 400 pounds per acre of this fertilizer are applied is shown in the following table:

| | Phosphoric Acid | Nitrogen | Potash |
|---|---|---|---|
| Outgo when 300 pounds of lint is grown per year | 9 lbs. | 37 lbs. | 9 lbs. |
| Income in 400 pounds fertilizer | 32 lbs. | 8 lbs. | 8 lbs. |
| Gain per year | 21 lbs. | ....... | ....... |
| Loss per year | ...... | 29 lbs. | 1 lb. |

The soil will gain in phosphoric acid and lose little potash if the crop is 300 pounds of lint, but the soil will be depleted of its nitrogen. The use of this fertilizer cannot maintain the fertility of the soil when used for continuous cotton cropping.

Cottonseed meal alone could be used in sufficient quantities to maintain the fertility of the soil. Five hundred pounds of cottonseed meal would supply approximately the quantity of nitrogen lost in taking off a crop of 300 pounds of lint; provided, the stalks and leaves are turned under and not burned. If they are burned, the loss of nitrogen would be greater and a larger quantity of cottonseed meal would be necessary.

The quantity of cottonseed meal mentioned would also be sufficient to restore the loss of phosphoric acid, and it would very nearly restore the loss of potash. As, however, many Texas soils are deficient in phosphoric acid, an addition of acid phosphate to cottonseed meal is advisable.

It is evident from what has been said that it is an easy matter to maintain the fertility of the soil with commercial fertilizer so far as potash and phosphoric acid are concerned, but the quantity of nitrogen required is very expensive in commercial fertilizers.

When cotton is grown continuously, with or without fertilizer, the soil may not only lose plant food, but its store of organic matter is depleted. The organic matter has considerably to do with maintaining the soil in a favorable physical condition. The better condition the soil is in, the more effective will be the fertilizer applied to it. Hence, even though the supply of plant food is maintained, the soil would lose in productiveness under continuous cotton (or corn) cultivation.

## FERTILIZERS FOR CORN.

Permanent fertility in connection with the growing of corn can be secured only with a proper crop rotation.

Ten bushels corn requires, for stalk, leaves and grain, approximately 15 pounds nitrogen, 6.25 pounds of phosphoric acid, and 10 pounds of potash. Two hundred and eighteen pounds cottonseed meal would contain 15 pounds nitrogen or more, and also 4.3 pounds phosphoric acid and 3.2 pounds potash. Thirty-nine pounds of 16 per cent acid phosphate would contain 6.25 pounds available phosphoric acid. Eightythree pounds of kainit, or 20 pounds of muriate or sulphate of potash, would contain 10 pounds of potash.

A mixture of acid phosphate and cottonseed meal constitute a good, all around fertilizer for use on corn. The proportion to make the mixture depends upon the soil and on the quantity used. A mixture of equal parts is excellent for many soils at the rate of 200 pounds per acre. If large quantities are used, the proportion of cottonseed meal should be increased; an additional mount of nitrogen is more likely to be utilized than an additional amount of phosphoric acid. On light sandy soils, or on old worn loams, potash is likely to be needed.

Acid phosphate at the rate of 100 to 200 pounds per acre gives good results for corn on well improved lands, or lands that are comparatively new, or some well-drained bottom lands which are deficient in phosphoric acid. This application will not maintain the fertility of the soil. In a comparatively short time the need of the soil will be for nitrogen rather than for phosphoric acid.

The use of fertilizers alone will be of only temporary advantage. In time, the rotation of crops will show itself to be a necessity. Rotation must include crops that procure nitrogen from the air and put it in the soil.

Nitrogen is entirely too expensive to purchase in the form of fertilizers to supply the entire needs of the corn crop. Corn uses about one and a half pounds of nitrogen in the production of a bushel. The valuation of this quantity of nitrogen would be 30 cents. All of the nitrogen put into the soil is not recovered by the plant. Probably one-fourth of it is lost, and sometimes the loss is very much greater. If one-fourth of the nitrogen were lost, it would take 38 cents worth of nitrogen to produce a bushel of corn. In addition, there is the cost of the hauling of the fertilizer and applying it. It is easily seen that the purchase of all the nitrogen required for the growing of corn would not be a profitable transaction.

It is profitable, at times, to purchase a small amount of nitrogen to supplement the nitrogen of the soil. But for profitable corn growing the nitrogen must be secured from the supply in the atmosphere. The rotation suitable for corn land has already been given in connection with cotton.

In Bulletin No. 138 of the Texas Experiment Station there are given the results of co-operative fertilizer experiments on corn. In thirty-one there was a gain due to the use of acid phosphate, in seventeen a gain was due to the use of cottonseed meal, which is used as a source of nitrogen; and in twelve there was a gain due to the use of potash. Acid phosphate at the rate of 200 pounds to the acre caused an increase of from five and a half to six and a half bushels of corn. The effects of the cottonseed meal were somewhat small. The potash gave good increases in yield where it was effective at all. But this is in only one-third of the experiments.

The following application has been recommended for corn on worn soils:

| | |
|---|---|
| Acid phosphate, 14 per cent | 900 pounds |
| Cottonseed meal | 900 pounds |
| Kainit | 150 pounds |

## FERTILIZERS FOR RICE.

A rotation of crops is a necessity for soil fertility and for the best results in growing rice. A rotation of crops will not only aid in the elimination of the weeds and red rice which become so troublesome, but it would place the soil in better condition for growing the crop and allow it a chance to become aerated. It would also store nitrogen, which is also needed. Rice growers should, therefore, arrange to plant, and graze off or turn under, a crop of peanuts, beans, velvet beans, cowpeas, vetch, or some other legume crop during alternate years. It may also be possible to discover some leguminous crop which may be planted in the fall after the rice has been harvested, and turned under in the spring at the time of planting.

Rice is usually planted on soils fairly well supplied with potash, sometimes well supplied with phosphoric acid, and usually well supplied with nitrogen to begin with. The rice growers usually waste all the potash which the plant removes from the soil. After a few years in cultivation, the rice lands fall off rapidly in production, and at this time are possibly most in need of nitrogen. They also need vegetable matter, and in many cases phosphoric acid. Potash is not needed, as a rule, until after the rice lands have been in cultivation a number of years, and only when the stores of potash if in the soil have been *wasted.*

The best form of nitrogen for the rice growers is probably sulphate of ammonia. It can be immediately taken up by the rice plant, and does not undergo injurious changes in the soil. Organic sources of nitrogen are also suitable, but the nitrogen in these forms does not change as readily in a soil saturated with water. Organic fertilizers are, therefore, not as effective as they are on cotton, or corn soils. Nitrate of soda should not be used for rice. When placed in a soil saturated with water and containing vegetable matter, nitrate of soda is rapidly destroyed. If the rice grower adopts a suitable rotation and secures nitrogen from the air by means of legumes and keeps his soil stored with vegetable matter, and does not waste the fertility in his soil, as is often the case, he will likely need only to purchase acid phosphate as a fertilizer, and there need be only a little loss of potash due to the natural cropping of the land in rice. There will be a great loss if the rice straw is burned and the ashes are scattered.

As fertilizers for rice, we would, therefore, suggest:

1. Acid phosphate at the rate of one hundred to two hundred pounds per acre on lands that produces a good straw but somewhat light grain.

2. Acid phosphate alone, in connection with a rotation of crops, including legumes grown for renovation.

3. A mixture of acid phosphate and sulphate of ammonia, the second or third year, or when the rice crop has begun to decrease in quantity. A fertilizer containing about 8 per cent. of available phosphoric acid and 4 per cent. nitrogen will give good results on some soils, but on other soils a heavier application of nitrogen is advisable. A mixture of 100 pounds 16 per cent. acid phosphate and 40 pounds sulphate of ammonia would contain the plant food in these proportions. But the quantity of nitrogen that will give the best results will, of course, depend on the condition of the soil as regards nitrogen and phosphoric

acid. It would probably be better for the rice grower to buy his acid phosphate and his sulphate of ammonia separately, and apply them in accordance with what he finds to be the needs of the crop.

The fertilizer best adapted to rice depends upon the nature of the soil and the treatment which it has received. The rice soils east of Houston, Texas, as a general rule, are deficient in phosphoric acid and respond well to applications of 100 to 200 pounds per acre of acid phosphate as long as the soil continues to supply sufficient nitrogen and potash. This supply lasts, however, a comparatively short time, and the use of acid phosphate can only be considered as a temporary method of fertilizing.

If the rice-straw ashes are removed from the soil, the potash will be rapidly depleted, but if they are returned, the loss of potash from rice soils is very small. Rice farmers who waste their rice-straw ashes will have to buy considerable amounts of potash sooner or later, while those who return the ashes to the soil will need to purchase comparatively little potash.

Fertilizers containing about 10 per cent. phosphoric acid and 2 or 4 per cent. potash also are used in the rice belt, but the use of such fertilizers in continuous rice culture can only be considered as a temporary expedient, though if used in connection with a suitable rotation they may be sufficient. Sooner or later the nitrogen of the soil will become deficient. It is doubtful if the use of the potash is of any advantage. It is also absurd to purchase fertilizer potash, when rice straw ashes, at hand and usually wasted, contain about 12 per cent. potash.

The following table shows the yearly gain or loss of plant food in a soil fertilized with this kind of fertilizer. We assume that 1900 pounds of rice is secured per acre, and an application of 200 pounds per acre of 10-4 fertilizer is made. It is necessary to make two sets of calculations; in one the rice straw is removed, and in the other the straw ashes are returned.

*Rice Straw Removed.*

| | Phosphoric Acid | Nitrogen | Potash |
|---|---|---|---|
| Loss in growing 1900 pounds rice.... | 15 lbs. | 57 lbs. | 42 lbs. |
| Gain from 200 pounds fertilizer...... | 20 lbs. | ....... | 8 lbs. |
| Gain ........................... | 5 lbs. | ....... | ....... |
| Loss ........................... | ...... | 57 lbs. | 34 lbs. |

It is evident from these figures that the fertilizer referred to cannot maintain the nitrogen or potash in rice soils, if the rice-straw ashes are wasted, as they should not be.

*Rice Straw Ashes Returned.*

| | Phosphoric Acid | Nitrogen | Potash |
|---|---|---|---|
| Loss in growing 1900 pounds rice.... | 12 lbs. | 57 lbs. | 5 lbs. |
| Gain in 200 pounds fertilizer........ | 20 lbs. | ....... | 8 lbs. |
| Gain ........................... | 8 lbs. | ....... | 3 lbs. |
| Loss ........................... | ...... | 57 lbs. | ....... |

So far as the phosphoric acid and potash are concerned, the fertility of rice soils can be easily maintained. The amount of nitrogen required by the crop referred to above would be contained in 800 pounds of cottonseed meal. Cottonseed meal, however, does not decay rapidly in rice soils, and the decay is necessary to release the plant food and make it available to plants.

It is seen that maintaining the fertility of rice soils is largely a question of maintaining the nitrogen supply. The best method of maintaining the nitrogen in rice soils will undoubtedly be rotation of crops in which leguminous crops are grown to take up the nitrogen from the air. This system of rotation must be worked out in the rice belt sooner or later, and the sooner the better for those concerned.

## IRISH POTATOES.

Irish potatoes should be grown in the course of a crop rotation, and if possible they should follow renovating legume crops. If grown in this way, they will have the advantage of nitrogen stored up by the legume, and also have the good effects of the vegetable matter added. In thirteen co-operative experiments with Irish potatoes, as quoted in Bulletin No. 138, acid phosphate gave gains in ten, nitrogen as represented by cottonseed meal gave a gain in every case and potash gave five gains.

The fertilizer that should be used on potatoes depends on the character of the soil, the previous treatment and its possibilities with good seed, good cultivation and average seasons. The greater the possibility of the land for producing high yields, the more fertilizer may be used, and the more likely it is that potash will be needed in addition to phosphoric acid and nitrogen. In the thirteen experiments mentioned above, potash gave results in only one-third of the cases; where a gain occurred, the potash was very effective. On light sandy soils which have been in cultivation for a number of years, potash is almost certain to be needed. On heavy soils, potash may have no effect, particularly if climate and soil conditions allow only a moderate crop to be produced.

Ten bushels potatoes require for leaves, stalk and tubers approximately 1.7 pounds phosphoric acid, 3 pounds nitrogen, and 4.8 pounds potash. Forty-four pounds of cottonseed meal contains 3 pounds nitrogen or more, and, in addition, about 0.9 pounds phosphoric acid and 0.7 pounds potash. Eleven pounds of 16 per cent. acid phosphate contains 1.7 pounds phosphoric acid. Forty pounds of kainit, or 10 pounds of muriate or sulphate of potash, contain 4.8 pounds potash or a little more.

A good fertilizer for potatoes on many soils consists of a mixture of equal parts of acid phosphate and cottonseed meal. This would give a fertilizer containing about 8 per cent. available phosphoric acid and 3½ per cent. nitrogen, and should be applied at the rate of 200 pounds per acre. If the application of a large quantity is desired, the proportion of nitrogen should be increased by increasing the quantity of cottonseed meal in greater proportion than the acid phosphate. On some soils the proportion of nitrogen should be increased, and on other soils it is better to use more phosphate. On the lighter sandy soils, the addition of potash is advisable.

Some of the soils on which potatoes are grown in Texas need potash, while others require very little at present. Until the different kinds of soils are studied, it is impossible to say which need potash and which do not. All of the potato soils appear to need phosphoric acid.

On soils which do not need potash, a mixture of equal parts of cottonseed meal and acid phosphate gives good results. This fertilizer is used extensively in East Texas for potatoes and also for tomatoes. The mixture is improved by replacing a part of the cottonseed meal with one-half as much nitrate of soda.

Top dressings of nitrate of soda are also sometimes made on potatoes.

Soils on which potatoes are grown very often will sooner or later need potash, as the potato plant requires a good deal of potash. For soils deficient in potash, a good potato fertilizer should contain from 3 to 4 per cent. nitrogen, 6 to 8 per cent. phosphoric acid, and 4 to 8 per cent. potash. The following formula is recommended by the Georgia Experiment Station for Irish potatoes:

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| Acid phosphate, 14 per cent | 1,000 pounds |
| Muriate of potash | 250 pounds |
| Nitrate of soda | 420 pounds |

This fertilizer would contain about 8.4 per cent. phosphoric acid, 4 per cent. nitrogen, and 7.5 per cent. potash. It is applied at the rate of 350 to 700 pounds per acre. It is doubtful if Texas soils need as much potash as is called for in the formula referred to.

Experiments at Troupe (Bulletin No. 101) show that phosphoric acid and nitrogen give good results, while potash was of little value. The following fertilizer is recommended for potatoes on soil such as that at the Troupe Station.

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|---|---|
| Acid phosphate, 14 per cent | 1,000 pounds |
| Cottonseed meal | 700 pounds |
| Kainit | 200 pounds |
| Nitrate of soda | 100 pounds |

This fertilizer contains 8 per cent. available phosphoric acid, 3.2 per cent. nitrogen, and 1.6 per cent. potash, and should be used at the rate of 400 to 600 pounds per acre.

As stated above, ten bushels of Irish potatoes use approximately 1.7 pounds phosphoric acid, 3 pounds nitrogen, and 4.8 pounds potash, for the entire plant. The greater the quantity of fertilizer which may profitably be used on the soil, the higher the percentage it should contain of nitrogen and potash. For example, 200 pounds of a fertilizer containing 8 per cent. available phosphoric acid and 3 per cent. each of nitrogen and potash will contain as much phosphoric acid as potato plants producing 100 bushels potatoes will. It will contain only as much nitrogen as potato plants producing 10 bushels potatoes, and only as much potash as potato plants producing 6 bushels. The nitrogen and the potash for the potatoes produced in excess of these quanties must come from the soil (assuming that *all* the fertilizer is available). But the greater the quantity of fertilizer the less is the probability that the soil will supply the nitrogen and potash needed for the large crop produced, and so the fertilizer should contain proportionately more nitrogen and potash when used in large quantity than when used in small quantity.

### SWEET POTATOES.

Sweet potatoes require well drained porous soils. Large applications of nitrogen are liable to cause the plant to run to vine rather than to produce potatoes, and are also said to impair the quality of the potatoes. The use of legumes in a rotation with sweet potatoes is to be highly recommended. Fertilizer may be used from 300 pounds up to 1200, but excessive quantities do not give good results where the season is likely to be dry.

A fertilizer containing 6 per cent. available phosphoric acid, 4 per cent nitrogen, aand 4 per cent. potash, gives excellent results on many sandy soils, at the rate of 300 to 400 pounds per acre. On loams, the potash may be omitted. If heavier applications are desired (and they may prove profitable in some sections of the State), the quantity of phosphoric acid should be decreased, and more nitrogen and potash used.

### ALFALFA.

Alfalfa is a plant which requires an abundance of lime and a well-drained soil. If the soil does not contain lime, the application of three tons per acre of ground limestone should be made before planting the alfalfa. The roots of alfalfa extend deeply into the soil after it has been well established. Alfalfa also has the power of taking nitrogen from the air. It is usually grown upon heavy soils which are well supplied with potash. For these reasons, the only fertilizer that need be recommended is acid phosphate. Acid phosphate is used to a considerable extent in some of the alfalfa regions of this State. Potash is little used. In European countries, alfalfa is used extensively in rotation, with other crops. The land is kept in the alfalfa two or three years and then broken up and other crops are then grown in rotation for two or three years longer. The alfalfa is a leguminous crop, adds nitrogen to the earth from the air, and also organic matter, on account of the leaves and other portions of the plant, dropping to the soil. A rotation of crops including alfalfa would be excellent for some sections of the State, and would be an advantage to both the alfalfa and the other crops. The rotation would allow for the elimination of the weeds, which in time kill out the alfalfa where grown continuously. The crops which follow the alfalfa utilize the accumulation of nitrogen in the soil. Alfalfa on old land may need potash, as it draws heavily on the soil potash.

### FERTILIZERS FOR ALFALFA.

Young alfalfa may receive benefit from fertilizers, especially on soils deficient in phosphoric acid. On such soils, we would suggest the use of the following mixture:

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| Acid phosphate, 14 per cent. | 1,000 pounds |
| Nitrate of soda | 100 pounds |
| Muriate of potash | 50 pounds |
| Total | 1,150 pounds |

This mixture should be applied at the rate of 200 or 300 pounds per acre and harrowed in before the seed are planted. The nitrate of soda and the muriate of potash aid in giving the young plant a vigorous start, and the phosphoric acid corrects the deficiency of the soil.

Alfalfa draws largely on the plant food of the soil. Four tons of alfalfa hay contain the following amounts of plant food:

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|---|---|
| Phosphoric acid | 50 pounds |
| Nitrogen | 183 pounds |
| Potash | 143 pounds |

Three hundred pounds of 16 per cent. acid phosphate would restore the loss in phosphoric acid. So would 110 pounds of rock phosphate (27 per cent.). Two hundred and ninety pounds of muriate of potash would restore the loss in potash. The phosphoric acid in rock phosphate is only slowly available, but would probably give good results on such crops as alfalfa.

A large part of the potash and phosphoric acid is withdrawn from the lower parts of the soil. The nitrogen is taken from the air, and alfalfa enriches the soil in this valuable form of plant food instead of making it poorer. The organic residues left by the crop also improve the physical character of the soil. For these reasons, alfalfa is a fine crop to grow in rotation with crops which can use the nitrogen of the soil, and not the nitrogen of the air.

Alfalfa appears to need lime, and is most successful upon calcareous soils. The calcareous soils of Texas, which are most suitable for the growth of alfalfa do not, as a rule, respond well to commercial fertilizers.

### FERTILIZERS FOR ONIONS.

The onion growers around Laredo, Texas, use fertilizers containing 6 to 8 per cent. phosphoric acid, 4 to 5 per cent. nitrogen, and 4 to 6 per cent. potash, at the rate of 1000 to 2000 pounds per acre. Many onion growers of New York prefer a fertilizer containing 8 per cent. phosphoric acid, 4 per cent. nitrogen, and 10 per cent. potash, at the rate of 1000 to 2000 pounds per acre. We doubt if such large quantities of potash are needed in Texas.

A crop of 30,000 pounds onions withdraws (in the bulbs) approximately the following amounts of plant food, on an average of five analyses of Bermuda onions grown at Laredo:

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|---|---|
| Phosphoric acid | 27 pounds |
| Nitrogen | 57 pounds |
| Potash | 60 pounds |

In addition, we may estimate the loss of nitrogen by seepage at 15 pounds per acre per year, making a total loss of 72 pounds per acre. It is seen that the nitrogen of the soil is lost to the greatest extent.

The loss or gain of an onion soil which received 1000 pounds on an 9-3-8 fertilizer is shown as follows:

| | Phosphoric Acid | Nitrogen | Potash |
|---|---|---|---|
| Loss in growing 30,000 pounds onions. | 27 lbs. | 72 lbs. | 60 lbs. |
| Gain from 1000 pounds fertilizer.... | 80 lbs. | 30 lbs. | 80 lbs. |
| Net gain ................ | 43 lbs. | ..... | 20 lbs. |
| Net loss .................. | ...... | 42 lbs. | ....... |

While this fertilizer increases the phosphoric acid and potash of the soil, the store of nitrogen is depleted. That is, this fertilizer will not maintain the nitrogen of the soil under continuous onion growing. The soil will, in time, need more nitrogen than is supplied in such a fertilizer. It appears that the quantity of nitrogen supplied in the fertilizer must be increased as time goes on.

Mr. T. C. Nye, near Laredo, states that he used cottonseed meal for onions at the rate of 1500 pounds per acre with very satisfactory results. The results of this fertilizer would be as follows:

| | Phosphoric Acid | Nitrogen | Potash |
|---|---|---|---|
| Loss in growing 30,000 pounds onions. | 27 lbs. | 72 lbs. | 60 lbs. |
| Gain from 1500 pounds cottonseed meal. | 37.5 lbs. | 150 lbs. | 22 lbs. |
| Net gain ................ | 9.5 lbs. | 33 lbs. | ...... |
| Net loss .................. | ...... | ....... | 38 lbs. |

Considering the fact that the soils of Laredo are pretty well supplied with phosphoric acid and potash, and can furnish some to the plant, it is not a matter for surprise that cottonseed meal alone should give such excellent results. It is probable, however, that some phosphoric acid and potash in addition to that in the meal would be of advantage.

Onion growing also causes the soil to lose its organic matter, which is very important to maintain the soil in a good physical condition. Manure should be applied or leguminous crops should be grown to supply the nitrogen which will be needed, and also the organic matter which the soil needs. A rotation of crops, in which alfalfa, cowpeas or some similar nitrogen-gathering crop is planted, would be of advantage to onion soils. An uncultivated crop, such as alfalfa, enriches the soil in organic matter also.

### FERTILIZERS FOR PEANUTS.

For peanuts on sandy soils, we suggest the use of a fertilizer containing 10 per cent. phosphoric acid and 4 per cent. potash, at the rate of 400 pounds per acre. Peanuts, especially the large varieties, on sandy soils deficient in lime, are greatly benefited by applications of lime, as it makes the nuts fill better. The lime may be applied in the form of quick-lime or air-slacked lime or ground limestone. The quantity of lime which gives the best results depends on the character of the soil. About 800 to 1200 pounds quick-lime per acre, or one to two tons of ground limestone, should give good results. On heavy soils, acid phosphate alone should give good results. We do not recommend the use of cottonseed meal or other nitrogenous fertilizer, as it should be more profitable to allow the peanuts to get their nitrogen from the air.

### FERTILIZERS FOR OATS.

On soils which need phosphoric acid, acid phosphate should be applied. Cottonseed meal, or cottonseed, often give good results on fall-sown oats. Since oats make a large growth in the spring, at the time when the agencies which prepare nitrogen for the use of plants are not very active, a top dressing of nitrate of soda at the rate of 100 pounds per acre has often proved profitable, especially on soils well supplied with phosphoric acid. The nitrate or meal should be broadcast thinly after the dew is off the plant.

### SUGAR CANE.

Thirty thousand pounds of stripped sugar cane stalks carry with them about twenty thousand pounds of leaves. They contain about 22.6 pounds phosphoric acid, 36 pounds of potash and 41 pounds of nitrogen.

It is highly important that between plantings of sugar cane the soil should be occupied with some other crop, preferably leguminous crops. One method consists of growing a crop of corn, followed by cowpeas and plowing under the cowpeas. According to experiments at the Louisiana Experiment Station, sugar cane soils should receive an annual application of 25 to 50 pounds of nitrogen and about 35 pounds of phosphoric acid. The amount of potash required would depend upon the character of the soil. Good clay soils, rich in organic matter, often do not require any potash. The fertilizer may be applied broadcast, and worked into the soil before planting, or it may be placed under the cane and covered with the soil at the time of planting. After the crop has been cut, the stubble cane is fertilized again about the time each sprout has sent out good shoots. Tankage containing about 8 per cent. nitrogen and 10 per cent. of phosphoric acid is a good fertilizer for cane on many soils.

### FERTILIZERS FOR MEADOWS.

There are a number of grass fields in the State, used for pasture, or on which the grass is cut for hay, on which fertilizers could profitably be applied. One some of these fields, it would be advisable to apply only acid phosphate at the rate of 100 to 150 pounds per acre; on others an application of 100 pounds of nitrate of soda would give profitable results. The nitrate of soda should be applied broadcast after the dew is off the grass, and scattered thinly over the land. On some meadows a mixture of the acid phosphate and the nitrate of soda would be advisable. Ground rock phosphate, which acts slowly and is not immediately available, would give good results on many meadows. It should be applied at the rate of about 500 pounds per acre.

### FERTILIZERS FOR WHEAT.

Wheat should always be grown in a rotation, in which legumes are grown, to be turned under or grazed off, for soil renovation. Where such a rotation is not practiced, it should be established as soon as possible. Acid phosphate alone at the rate of 100 to 150 pounds per acre will give good results on some wheat lands, particularly where there is a good growth of straw, but a deficiency in grain. It is advisable that the nitrogen should be secured from the air as much as possible. Many of the stronger wheat soils contain an abundance of potash, and the use of potash in a fertilizer in such cases is useless. A fertilizer containing about 8 per cent. available phosphoric acid, 3 per cent. of potash and 3 per cent. nitrogen, at the rate of 200 to 500 pounds per acre, gives good results on some wheat lands, especially those long under cultivation. If more than 300 pounds of fertilizer is to be used, however, it would often be advisable to use a fertilizer containing about 6 per cent. available phosphoric acid, 4 per cent. nitrogen and 4 per cent. potash.

### CABBAGE.

A crop of 20,000 pounds of cabbage will contain, in the heads, approximately 60 pounds of nitrogen, 20 pounds of phosphoric acid and 80 pounds of potash. The best fertilizer to use will depend upon the conditions under which the cabbage is grown. It is desirable to grow cabbage in connection with a good rotation of crops, not only for the sake of the physical and chemical conditions which are rendered favorable, but for the further reason that insect injury and plant diseases are less liable to affect the crop grown in rotation. Where cabbage is grown as an early crop, it can be followed during the same season by another crop, and it is very desirable that such crop should be one which aids in renovating the soil. Fifteen to twenty tons per acre of farm manure have given good results on cabbage. A fertilizer containing 5 per cent. available phosphoric acid, 5 per cent. nitrogen and 5 per cent. potash has also given good results. On other soils it is desirable to use more phosphoric acid and less nitrogen and potash, and on some sandy soils it is better to use higher percentages of potash. For cabbages forcing to early maturity, nitrate of soda properly used gives excellent results.

### WATERMELONS.

Watermelons, cucumbers, muskmelons, pumpkins, and similar crops, do best if the soil is well supplied with organic matter. When they are not grown in rotation with leguminous crops, it is well to make liberal applications of well rotted manure. The manure may be placed in a hole and covered with the soil to a depth of 3 to 4 inches and the seed planted on this, and covered with 2 or 3 inches of additional soil. A more convenient method and probably better suited to Texas conditions, is to apply the manure in liberal amounts to the portions of the plowed ground where rows are to be planted, and work it into the soil very thoroughly. If fertilizer is desired, 300 pounds per acre of a fertilizer containing 8 per cent. available phosphoric acid, 3 per cent. potash and 3 per cent. nitrogen may give good results on some soils.

If it is desired to use larger quantities of fertilizer, a fertilizer containing about 5 per cent. available phosphoric acid, 5 per cent. nitrogen and 5 per cent. potash would be better. Six hundred to 1000 pounds of fertilizer containing about 4 per cent. nitrogen, 8 per cent. available phosphoric acid and 10 per cent. potash is recommended by Dr. Van Slyke, of the New York Experiment Station. On some of the heavy Texas soils, the use of potash is needless, as the soil contains plenty of potash.

### FERTILIZERS FOR OTHER CROPS.

Suggestions in regard to the use of fertilizers will be made by the Chemist of the Experiment Station upon application. Care should be taken to state the kind of soil, its location, depths, previous treatment, and any other information that will throw light on the probable needs of the soil. Such information aids greatly in suggesting fertilizers applicable to the crop and the conditions.