
PLANT FOOD
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PLANT FOOD

ITS NATURE, COMPOSITION AND MOST PROFITABLE USE

PREPARED TO AID

PRACTICAL FARMERS

PUBLISHED BY THE

Supervising Committee of the Experimental Farms

OF THE

North Carolina State Horticultural Society,

SOUTHERN PINES, N. C.

Publications

issued by the Supervising Committee are free to farmers. The Committee publishes Annual Reports about the Farm of a Scientific Nature; also popular treatises about Manuring plants, etc.

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EXPERIMENTAL FARMS,

SOUTHERN PINES, N. C.

TABLE OF CONTENTS.

PREFACE.

This book has been compiled from Bulletin No. 94 (new series), issued by the New York Agricultural Experiment Station at Geneva, N Y. The original Bulletin, which was prepared by Dr. L. L. Van Slyke, has been thoroughly revised with his approval and authority, and many of the technical and scientific details are omitted. However, all the main points of interest and importance are given in this book, which is offered to the careful study and consideration of intelligent and practical farmers everywhere.

INTRODUCTION.

THIS treatise should be carefully studied. It is not enough to merely read it over ; the whole foundation of scientific manuring is given as briefly as possible, but a mere casual reading will not make it of practical use to the average farmer. It must be studied. Possibly the best plan would be to take it up in sections, and read and re-read until the points involved become familiar.

The farmer must bear in mind that with modern competition, he cannot afford to neglect the slightest detail. A careful study of this book will enable him to buy and use the different forms of manures and fertilizers as intelligently as the progress in agricultural science permits. The book should be constantly kept at hand for convenient reference.

Manure and fertilizers are one and the same thing—all manures and fertilizers are merely so much nitrogen, potash, and phosphoric acid. It is as well for the reader to try and not think of manure as so much refuse from the stables, but rather as substances containing so much **nitrogen, potash, and phosphoric acid.**

THE FOUR FUNDAMENTAL LAWS.

The systematic scientific study of agriculture was commenced about fifty years ago, and it is to the celebrated

German agricultural chemist Justus von Liebig we owe the following four elementary laws, which are the foundation of the best modern practice.

I. A soil can be termed fertile only when it contains all the materials necessary for the nutrition of plants, in the required quantity, in the proper form.

II. With every crop a portion of these ingredients is removed. A part of this is again added from the inexhaustible store of the atmosphere; another part, however, is lost forever if not replaced by man.

III. The fertility of the soil remains unchanged if all the ingredients of the crop are given back to the soil. Such a restitution is effected by manure or fertilizers.

IV. The manure produced in the course of farming is not sufficient to maintain permanently the fertility of a farm; it lacks the constituents which are annually sold in the shape of grain, hay, milk, and live stock.

These laws cover the whole subject, but to understand them so that they may be applied at work in the field, it is necessary to have a fair idea of the sources of plant-food of the different kinds, and how best to use these different kinds for different crops.

PART I.

CHEMISTRY OF FERTILIZERS.

It is generally understood that all manures or fertilizers are valuable for the nitrogen, potash, or phosphoric acid they contain. Though other substances are needed for plant growth, they are almost always present in the soil in sufficient quantity. Lime might be made an exception, although its use is largely to improve the mechanical condition of the soil, and cure it of sourness. Lime also aids in rotting the vegetable matter.

NITROGEN AS A FERTILIZER.

The influence of nitrogen in its various forms upon plant growth is shown by at least three striking effects.

First. The growth of stems and leaves is greatly promoted, while that of buds and flowers is retarded. Ordinarily, most plants, at a certain period of growth, cease to produce new branches and foliage, or to increase those already formed, and commence to produce flowers and fruits, whereby the species may be perpetuated. If a plant is provided with as much available nitrogen as it can use just at the time it begins to flower, the formation of flowers may be checked while the activity of growth is transferred back to and renewed in stems and leaves, which take on a new vigor and multiply with luxuriance Should flowers be produced under these circumstances, they are often sterile and produce no seed.

Second. The next effect of nitrogen upon plants is to deepen the color of the foliage, which is a sign of increased vegetative activity and health.

Third. Another effect of nitrogen is to increase in a very marked degree the relative proportion of nitrogen in the plant.

POTASH AS A FERTILIZER.

Potash is essential to the formation and transference of starch in plants. Starch is known to be first formed in the leaves of plants, after which in some way it becomes soluble enough within the plant cells to enable it to pass through the cell-walls gradually and later to be carried into the fruit, where it accumulates and changes back to its insoluble form. It is well established that potash is intimately connected with the formation of starch in the leaves and with its transference to the fruit. No other element can take the place of potash in performing this work. Potash is important on account of its influence upon the development of the woody parts of stems and fleshy portions of fruits.

PHOSPHORIC ACID AS A FERTILIZER.

Experiments have shown that plants will die before reaching maturity, unless they have phosphoric acid to feed upon. Phosphates appear to perform three distinct functions in plants.

First. They aid in the nutrition of the plant by furnishing the needed quantities of phosphoric acid.

Second. They aid the plant, in some way not well understood, to make use of or assimilate other ingredients. Phosphates are found in the seeds of plants, and, as already stated, a plant does not come to maturity and so does not produce seeds, unless phosphates are present in the soil for the plants to feed upon. The liberal application of available phosphate compounds appears to hasten the maturity of plants.

Third. Certain forms of phosphates render the albuminoids sufficiently soluble to enable them to be carried from the growing parts of plants to the seeds, in which they accumulate in quantity.

THE FUNCTION OF LIME.

The chief function of lime is to improve the mechanical condition of the soil by loosening heavy clay soils and also by holding together and giving body to light sandy soils. Lime aids in the decomposition of animal and vegetable matter, such as vegetable mould, stable-manure, etc., and tends to convert them into available plant-food.

In using lime, care should be taken not to use too large quantities at a time; and, ordinarily, it is best to use it in connection with liberal applications of nutritive fertilizers. Lime can be used with much advantage on freshly drained swamp-lands and also on lands newly cleared.

TERMS USED IN STATING FERTILIZER ANALYSES.

Fertilizer dealers, and the Experiment Station Bulletins treat the different forms of fertilizer materials separately, and it is important that the farmer should be familiar with these trade names, and understand what they mean.

The following list contains most of the terms used in stating fertilizer analyses.

Nitrogen is expressed as

(*a*) Nitrogen, (*b*) Ammonia, (*c*) Nitrogen equal (or equivalent) to Ammonia.

Phosphoric Acid is expressed as

(*a*) Phosphoric Acid, (*b*) Soluble Phosphoric Acid, (*c*) Reverted Phosphoric Acid, (*d*) Precipitated Phosphoric Acid, (*e*) Available Phosphoric Acid, (*f*) Soluble and Available Phosphoric Acid, (*g*) Insoluble Phosphoric Acid, (*h*) Total Phosphoric Acid, (*i*) Phosphoric Acid equal (or equivalent) to Bone Phosphate of Lime.

Potash is expressed as

(*a*) Potash, (*b*) Potash (actual), (*c*) Potash S. (or Sul.), (*d*) Potash (Soluble), (*e*) Potash as Sulphate, (*f*) Potash equal (or equivalent) to Sulphate of Potash, (*g*) Sulphate of Potash, (*h*) Potassium Oxide.

NITROGEN.

(*a*) *Nitrogen* is a gas and, in this form, cannot be used in fertilizers. Therefore, whenever we speak of nitrogen in fertilizers, we do not mean that nitrogen exists in them as simple nitrogen. The nitrogen in fertilizers is always combined with other elements, and may be present in one or more different forms:—(1st) in the form of Nitrates, as nitrate of soda; (2nd) in the form of Ammonia compounds, as sulphate of ammonia; and (3rd) in the form of organic matter, animal or vegetable, as dried blood, meat, tobacco-stems, etc. Chemical analysis according to official methods does not attempt to ascertain and state in which form or forms the nitrogen is present in a fertilizer.

When, therefore, nitrogen is expressed in an analysis or guarantee as "nitrogen," it refers to the entire amount of nitrogen present without regard to the particular form or forms in which it is present.

(*b*) *Ammonia* consists of nitrogen combined with hydrogen. A pound of nitrogen will form more than a pound of ammonia, because the ammonia formed from a pound of nitrogen will contain that pound of nitrogen plus the necessary amount of hydrogen added to form ammonia. The chemical relations of nitrogen and ammonia are such that 14 pounds of nitrogen will unite with exactly three pounds of hydrogen, and will, therefore, produce just 17 pounds of ammonia; or one pound of nitrogen will make 1.214 pounds of ammonia.

(*c*) *Nitrogen equal or equivalent to Ammonia* is a form of expression which simply means that the nitrogen is stated not as nitrogen but as ammonia.

It would be better on every account if all guarantees stated simply nitrogen and never mentioned ammonia at all. As a matter of fact, compounds of ammonia are quite uncommon in commercial fertilizers, because nitrogen in this form is the most expensive and, therefore, least used. Strictly speaking, the term ammonia should never be used except when sulphate of ammonia or some similar compound is present in the fertilizer.

PHOSPHORIC ACID.

(*a*) *Phosphoric Acid*, as used in connection with fertilizers, is a compound containing phosphorus and oxygen, which in fertilizers is found never by itself, but in combination with lime. Phosphoric acid stands for a certain amount of phosphate of lime. We may say roughly that one part of phosphoric acid is equivalent to about two parts of phosphate of lime. But we know that phosphoric acid exists in several different forms.

(*b*) *Soluble Phosphoric Acid* represents the amount of phosphate of lime that dissolves easily in water; it is formed by treating with sulphuric acid some form of insoluble lime phosphate, such as bones, bone-ash, South Carolina rock, etc. The phosphate thus formed is readily soluble in water.

(*c*) *Reverted Phosphoric Acid* is formed from soluble phosphoric acid under certain conditions into which we need not inquire here. Suffice it to say that the soluble compound of phosphoric acid often changes, to some extent, on standing into a form, which while less soluble, is still quite readily available as plant-food.

(*d*) *Precipitated Phosphoric Acid* is simply another name for reverted phosphoric acid.

(*e*) *Available Phosphoric Acid* includes both the soluble and reverted forms of phosphoric acid, because both forms are available for the use of plants.

(*f*) *Soluble and available Phosphoric Acid* is an expression which means the same as available.

(*g*) *Insoluble Phosphoric Acid* represents the form of phosphoric acid in raw phosphate of lime, and which is of least value for agricultural purposes.

(*h*) *Total Phosphoric Acid* represents the entire phosphoric acid compounds without regard to the forms in which they exist. The total phosphoric acid is, therefore, the sum of the soluble, reverted and insoluble forms; or, to state it in another way, the sum of the available and insoluble forms.

(*i*) *Phosphoric Acid equal (or equivalent) to Bone Phosphate of Lime* is an expression which usually means nothing more nor less than insoluble phosphoric acid.

POTASH.

(*a*) *Potash*, as used in connection with fertilizers, always means a compound containing potassium and oxygen, known chemically as potassium oxide. Potash is never found as such in fertilizers, but chemists use this form of expressing the results of analyses as a convenient standard for reference. Fertilizers generally contain potash in such forms as sulphate of potash, muriate of potash, or carbonate of potash. Instead of stating the amount of sulphate, muriate or carbonate of potash present in a fertilizer, its equivalent amount is stated only in the form of actual potash in giving the results of analyses.

(*b*) *Potash actual* is simply another name for potash, as distinct from sulphate, muriate, etc.

(*c*) *Potash S. (or sul.)* means sulphate of potash. This is quite often used by manufacturers in giving guarantees.

(*d*) *Potash soluble* represents the amount of potash that dissolves in water and is available for the use of plants. The different forms of potash commonly used in fertilizers are readily soluble in water.

(*e*) *Potash as Sulphate* means simply sulphate of potash.

(*f*) *Potash equal* (*or equivalent to Sulphate of Potash*) is an expression which means simply sulphate of potash.

(*g*) *Sulphate of Potash* signifies that this compound is actually present in the fertilizer, and that there is no muriate present.

(*h*) *Potassium Oxide* means the same as potash, or actual potash.

LOSS OF FERTILIZER CONSTITUENTS FROM THE SOIL.

Phosphoric Acid. The phosphoric acid in raw materials such as ground bone or ground phosphate does not readily leach out of the soil. In specially prepared materials, however, like dissolved bone or dissolved phosphate (acid phosphate) the phosphoric acid is quite soluble and would be removed from the soil by drainage water, were it not for the fact that immediately after application the phosphoric acid becomes changed into another form which is not apt to leach away.

Nitrogen. The mineral forms of nitrogen such as nitrate of soda and sulphate of ammonia, both dissolve easily in water, hence they would soon wash into the subsoil and out of reach of the plants. The so-called organic forms of nitrogen like cotton-seed-meal, tankage, fish-scrap, dried-blood, etc., are less soluble, and experience indicates that they are largely retained in the soil. It is a matter of observation also that there is little loss of nitrogen by drainage when the soil is covered with vegetation, because the roots of the growing plants absorb nitrogen very readily.

Potash. It has been found by experience that the potash salts do not wash away to any appreciable extent because they form certain combinations in the soil which are not so soluble, but which at the same time are readily available to the growing crop.

In addition it may be said, in general, that loss of plant-food is greatest in sandy soils ; the coarser the sand, the greater the loss, the other conditions being the same. Clay and humus have very marked power in retaining plant-food.

General View of Vegetable Department, Experiment Farm, Southern Pines, North Carolina.

PART II.

DESCRIPTION OF FERTILIZER MATERIALS.

INDIRECT FERTILIZERS.

A stimulant or indirect fertilizer is one which does not in itself furnish directly to the soil any needed plant-food, but whose chief value depends upon the power it possesses of changing unavailable into available forms of plant-food. The stimulant or indirect fertilizers which have been most commonly employed are lime, gypsum and common salt.

Gypsum, or *Land-Plaster*, known also as calcium sulphate or sulphate of lime, in some manner aids the process of nitrification, by which ammonia and the nitrogen of organic matter are converted into nitric acid and nitrates. It also acts upon the insoluble forms of potash and other elements of plant-food, converting them into soluble and available forms; it is of value on certain soils to certain crops, such as clover, peas, lucerne and similar plants.

Quicklime or *Burnt Lime*, or calcium oxide, commonly called lime, produces changes in both the physical and the chemical character of soils. Freshly burned lime acts chemically upon soils by decomposing vegetable and mineral matter already present in the soil and changing them into forms which are available as food for the plant. Thus, lime acts upon insoluble mineral substances containing potash, etc., and converts them into soluble forms. Lime aids in the decomposition of animal and vegetable matter, such as vegetable mould, stable-manure, etc., and tends to convert them into available plant-food. In using lime, care should be taken not to use too large quantities at a time, and, ordinarily, it is best to use it in connection with liberal applications of nutritive fertilizing substances. Lime can be used to advantage on freshly drained swamp-lands and also on lands newly cleared.

Common salt has an indirect fertilizing value which is mainly due to the fact that it has the power of changing unavailable forms of plant-food, especially potash, into available forms.

Danger in using Stimulant Fertilizers. It should be kept in mind that these stimulant fertilizers—that is, gypsum (or plaster), lime, and salt,—are not used for the plant-food contained in them ; hence, as used, they do not furnish needed plant-food. The chief value of their use lies in the fact that they can change unavailable into available forms of plant-food. It can readily be seen that, when stimulant fertilizers are used exclusively for a term of years, the soil each year loses nitrogen, potash and phosphoric acid, which are not replaced. The inevitable result of such treatment is the exhaustion of these important food constituents from the soil. This affords an explanation of the question often raised now as to why the application of land-plaster does not give such results in crop yields at present as in former days. When land-plaster was the only fertilizing material added to soils for years in succession, it was possible to produce increased crops so long as there were in the soil enough compounds of nitrogen, potassium and phosphorus to be rendered available by the action of the land-plaster. When, therefore, these forms of plant-food were largely removed, there was nothing for the land-plaster to act upon, in orde to increase the supply of available food material. The land-plaster furnished no needed food but simply helped the crop to use more rapidly the store of plant-food present in the soil.

DIRECT FERTILIZERS.

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

Nitrate of Soda, known also as "Chili saltpeter," is found in large deposits which have been formed in the rainless regions of Chili and Peru. Good commercial nitrate of soda contains from $15\frac{1}{2}$ to 16 per cent. of nitrogen.

Sulphate of Ammonia is formed from waste materials produced in the manufacture of illuminating gas or coke. Sulphate of ammonia contains about 25 per cent. of ammonia, which is equivalent to about $20\frac{1}{2}$ per cent. of nitrogen.

Cotton-Seed-Meal is the product formed by removing the oil from cotton-seed by pressure, after which the material is dried and ground. Cotton-seed-meal contains about 7 per cent. of nitrogen, 3 per cent. of phosphoric acid and 2 per cent. of potash. The hulls of the cotton-seed also possess considerable fertilizing value.

Tobacco-Stems are the refuse from tobacco-factories. They contain usually from 5 to 8 per cent. of potash, 2 to 3 per cent. of nitrogen, and a small quantity of phosphoric acid.

Dried-Blood consists of blood obtained from slaughtering animals; it is prepared for market by evaporating, drying and grinding. The color varies from red to black. Dried-blood contains from 10 to 15 per cent. of nitrogen.

Dried-Fish, *Scraps* and *Ground-Fish* consist of refuse from fish-oil works and canneries; it is dried and ground for market. Dried ground-fish, of good quality, contains from 7 to 8 per cent. of nitrogen, together with as much or more insoluble phosphoric acid.

Meat-Scraps, *Tankage*, etc., are slaughter-house refuse, dried and ground. Good tankage contains 10 per cent. or more of nitrogen and often 10 per cent. or more of insoluble phosphoric acid.

Nitrogenous Guanos are formed in dry regions. The Peruvian guano was rich in nitrogen, containing 7 per cent. or more. They usually contain 7 to 12 per cent. phosphoric acid, and about 1 per cent. potash.

Bones consist mostly of calcium phosphate or phosphate of lime, which constitutes from one-half to three-fifths of the weight of the bone. The remaining portion is a soft, flesh-like substance commonly called gelatin. It is distributed throughout the entire mass of bone, and is rich in nitrogen.

When bones are burned, the nitrogenous matter is driven off and only the mineral portion or phosphate of lime remains. Bones such as are used in making commercial fertilizers, contain 4 to 5 per cent. of nitrogen, and from 20 to 25 per cent. of phosphoric acid, about $\frac{2}{3}$ of which is insoluble and approximately $\frac{1}{3}$ available.

Bone-Ash is made simply by burning bones in the open air. The nitrogen is lost in burning, and the chief constituent is insoluble calcium phosphate, equivalent to 30 to 35 or more per cent. of phosphoric acid for the most part insoluble.

Bone-Black, known also as bone-charcoal, is extensively used in refining sugar. After it has been used several times, portions become useless for refining purposes, and are then sold as a fertilizer. It is made by heating bones in closed vessels; the fat, water and nitrogen are driven off, and the bone-black remaining consists mainly of insoluble calcium phosphate and carbon or charcoal. Good bone-black may contain 30 or more per cent. of phosphoric acid mostly insoluble.

Bone-Meal goes under various names, such as ground bone, bone-flour, bone-dust, etc. Raw bone-meal contains the fat naturally present in bones. The presence of the fat is objectionable, because it retards the decomposition of the bone in the soil, while fat itself has no value as plant-food. The presence of easily decaying nitrogen compounds in bone hastens, in the process of decomposition, to dissolve more or less of the insoluble phosphate. Bone-meal should contain from 3 to 5 per cent. of nitrogen, and from 20 to 25 per cent. of phosphoric acid ; about one-third to one-fourth of the latter appears to be in readily available condition. Raw bone-meal generally contains somewhat more nitrogen (1 or 2 per cent.) and rather less phosphoric acid than steamed bone-meal. The fineness of the meal affects its value ; the finer the meal, the more readily available it is for plant-food.

Phosphatic Guanos, or *Rock Guanos.* Guanos generally consists chiefly of the dung of sea-fowls, though the term is applied to other animal products. They are generally found in beds resembling earthy deposits. The guanos which are called phosphatic contain little or no nitrogen. Their phosphoric acid is generally in the insoluble form. These guanos come mainly from certain islands in the Pacific Ocean, and from Caribbean Sea and West India Islands. The phosphoric acid in guanos is very variable, ranging from below 15 to over 30 per cent.

Rock Phosphates are known under several different names which generally designate the localities from which they come, as South Carolina Rock, Florida Rock, Tennessee Rock, West India Rock, etc. Other forms of mineral phosphates are known under the names of apatite, coprolite, and phosphorite, which are found in various places in America and Europe, and some of which are used in making commercial fertilizers. The rock phosphates are extensively used in making acid phosphates. When ground to a very fine flour-like powder, rock phosphates are called "floats." Rock phosphates contain usually from 25 to 30 per cent. of insoluble phosphoric acid, and some as much as 35 to 40 per cent.

Acid Phosphates are known under several different names, such as superphosphates, dissolved bone, dissolved Rock, dissolved bone-black, etc. Acid phosphates are formed by treating some form of insoluble phosphate of lime, as rock-phosphate, bone, bone-ash, etc., with sulphuric acid. By this treatment there are formed soluble phosphate of lime and gypsum (sulphate of lime) in nearly equal proportions. Superphosphate made from rock phosphates may contain from 12 to 18 per cent. of available phosphoric acid.

Thomas Slag, also known under several other names, such as basic iron slag, Thomas scoria, Phosphate slag, etc. It is a by-product formed in the manufacture of iron and steel from certain kinds of iron ore containing phosphorus compounds. It usually contains between 19 and 20 per cent. of total phosphoric acid, with 6 to 7 and more per cent. of available phosphoric acid.

Cotton-Seed-Hull Ashes were produced in the South at the cotton-seed-oil factories, where the hulls, after being removed from the cotton-seed, were used as fuel. Such ashes contain from 15 to 25 per cent. of potash, in addition to from 7 to 10 per cent. of phosphoric acid. This material is not commonly found now.

Kainit is the most commonly imported product of the German potash mines. It is a mixture of several different compounds, containing about 12.5 per cent. of actual potash together with about 35 per cent. of common salt, also magnesia salts.

Muriate of Potash, a manufactured salt from products of the Stassfurt mines, is the main source of supply for potash for commercial fertilizers in our market, and contains 50 to 53 per cent. of actual potash.

Sulphate of Potash is also a manufactured salt from products of the German mines. The product found in the market contains from 48 to 51 per cent. of actual potash.

Sulphate of Potash-Magnesia is known also as double manure salt or low grade sulphate of potash. This material comes from the German mines and contains 26 to 28 per cent. of actual potash. It also contains 32 to 36 per cent. of sulphate of magnesia.

Carbonate of Potash-Magnesia contains about 18 per cent. potash and 19 per cent magnesia, both as carbonates. It is practically free of chlorine. It is also a product of the German potash mines.

Wood-Ashes contain more or less potash, which is present chiefly in the form of carbonate. The amount of potash in commercial wood-ashes varies from below 4 to over 7 per cent., the average being under 5 per cent. Wood-ashes also contain between 1 and 2 per cent. of phosphoric acid.

The following are inferior sources of nitrogen. They are all very slowly available, and should be used only where immediate effects are not sought. In some States the fertilizer laws either prohibit the use of these substances in fertilizers or demand that these goods shall be specified when used in making mixtures.

Hair is obtained from slaughter houses; it is often mixed with dried blood and other forms of animal matter. It contains about 15 per cent. of nitrogen.

Hoof-Meal and *Horn-Dust* are by-products containing

10 to 15 per cent. nitrogen and about 2 per cent. phosphoric acid. They are sometimes treated with super-heated steam or with sulphuric acid, the treatment rendering the nitrogen compounds more readily available.

Leather-Scraps and *Leather-Meal* are waste products of various factories. When treated with super-heated steam and dried or roasted, they can be finely ground. They contain 7 to 8 per cent. nitrogen which, however, is not in a readily available form.

FARM-PRODUCED FERTILIZING MATERIALS.

Stable or farmyard manure consists of the solid and liquid excrements of the animals fed on the farm, mixed with straw and waste products of the farm.

Horse-Manure is difficult to mix thoroughly with litter on account of its being very dry. It is called a "hot" manure, because, on account of its loose texture, it easily undergoes decomposition or fermentation, producing a high degree of heat. On this account it is very liable to lose more or less of its nitrogen in the form of ammonia.

Sheep-Manure is quite dry, and is commonly the richest of farm produced manures. Like horse-manure, it undergoes fermentation easily and is classed as "hot" manure. It is similarly very liable to lose ammonia.

Pig-Manure varies greatly in composition, but is generally rich as compared with other farm-produced fertilizer materials, and contains considerable water. In decomposing, it produces but little heat, and is, therefore, called a "cold" manure.

Cow-Manure contains, as a rule, less fertilizing materials than any of the preceding manures. It contains a large amount of water, and, in decomposing, generates little heat.

Poultry-Manure contains a comparatively large amount of all the different forms of plant-food, being especially rich in nitrogen and phosphoric acid. It undergoes fermentation readily, and loses nitrogen unless properly treated with absorbents or preservatives.

Generally speaking, manures produced from working or fattening animals contain from 90 to 95 per cent. of the fertilizing constituents contained in the food. Manure made from cows in milk and young, growing animals contains from 50 to 85 per cent. of the fertilizing constituents contained in the food. In the case of animals which are neither increasing in weight, nor giving milk, the amount of fertilizing materials in the manure will be nearly equal to that contained in the food eaten. The foregoing statements presuppose that all the dung and urine are saved, a supposition which is not often true, considering the manner in which stable-manure is commonly treated.

Perhaps the element of manures least understood is the humic matter, of which ordinary manures contain from 16 to 20 per cent. The litter used in bedding stock furnishes much of this, and the quantity depends upon the nature of the material used.

COMPOSITION OF FERTILIZER MATERIALS USED AS SOURCES OF NITROGEN.

	Nitrogen.	*Equivalent in Ammonia.*	*Potash* K_2O.	*Phosphoric Acid. Total.*
Nitrate of Soda	15 to 16	18 to 19½	......	....
Sulphate of Ammonia	19 " 22	23 " 26	......	....
Dried-Blood (high grade)	12 " 14½	14½ " 17½	......	....
Dried-Blood (low grade)	10 " 11	12 " 14½	......	3 to 5
Concentrated Tankage	11 " 12½	13½ " 15	......	1 " 2
Tankage	5 " 6	6 " 7½	......	11 " 14
Tankage	7½ " 9	9 " 11	......	8½ " 10½
Dried Fish-Scrap	9½ " 11	11½ " 13½	......	6 " 8
Cotton-Seed-Meal	6½ " 7½	8 " 9	1½%	2%
Castor Pomace	5 " 6	6 " 7½	1%	2%
Tobacco-Stems	2 " 3	2½ " 4	5 to 8	about 1%

COMPOSITION OF FERTILIZER MATERIALS USED AS SOURCES OF PHOSPHORIC ACID.

	Nitrogen.	*Equivalent in Ammonia.*	*Potash, K_2O*	*PHOSPHORIC ACID.*		
				Total.	*Available.*	*Insoluble.*
So. Carolina Phos. Rock	....	....	....	26 to 27	....	26 to 27
So. Carolina Acid Phosphate	....	....	....	13 " 16	12 to 15	1 " 3
Florida Land Rock	....	....	....	33 " 35	....	33 " 35
Florida Pebble Phosphate	....	....	....	26 " 32	....	26 " 32
Florida Acid Phosphate	....	....	....	14 " 19	13 to 16	1 " 3
Tennessee Phosphate	....	....	....	34 " 39	....	34 " 39
Tennessee Acid Phosphate	....	....	....	14 " 19	13 to 16	1 " 3
Bone-Black (spent)	....	....	....	32 " 35	....	32 " 35
Bone-Black (dissolved)	....	....	....	17 " 19	16 to 17	1 " 2
Bone-Meal	$2\frac{1}{2}$ to $4\frac{1}{2}$	3 to $5\frac{1}{2}$	....	20 " 25	5 " 8	15 " 17
Bone (dissolved)	2 " 3	$2\frac{1}{2}$ " $3\frac{1}{2}$	....	15 " 17	13 " 15	2 " 3
Peruvian Guano	6 " 10	$7\frac{1}{4}$ " 12	$1\frac{1}{2}$ to 4	10 " 15	.. 8	2 " 7

COMPOSITION OF FERTILIZER MATERIALS USED AS SOURCES OF POTASH.

	Pure Potash, (K_2O) Per Cent.	Lime, Per Cent.	Nitrogen, Per Cent.	Ammonia, Per Cent.	Phosphoric Acid, Total, Per Cent.	Chlorine, Per Cent.
Muriate of Potash	50	......	......	......	....	45 to 48
Sulphate of Potash (high grade)	50 to 55	......	......	......	....	0.3 " 1.5
Sulphate of Potash Magnesia	27 " 30	0.85	......	......	....	1.5 " 2.5
Carbonate of Potash Magnesia	18½	......	......	......	....	....
Kainit	12.4	1.12	......	......	....	30 to 32
Sylvinit	16 to 20	......	......	......	....	42 " 46
Cotton-Seed-Hull Ashes	20 " 30	10	......	......	7 to 8	....
Nitrate of Potash or Saltpeter	43 " 45	......	13 to 14	16 to 17	....	....
Wood-Ashes (unleached)	2 " 8	30 to 35	......	......	1 to 2	....
Wood-Ashes (leached)	1 " 2	35 " 40	......	......	1 " 1½	....
Tobacco-Stems	5 " 8	3.5	2 to 3	2½ to 3½	....	....

AVERAGE COMPOSITION OF THE MOST IMPORTANT FARM MANURES.

FARM MANURES.	*Nitrogen.*	*Equivalent in Ammonia.*	*Potash.* (K_2O)	*Phosphoric Acid.* (P_2O_5)	
				Total.	*Lime.*(CaO)
Cow-Manure (fresh)	0.34	0.41	0.40	0.16	0.31
Horse-Manure (fresh)	0.58	0.70	0.53	0.28	0.21
Sheep-Manure (fresh)	0.83	1.00	0.67	0.23	0.33
Hog-Manure (fresh)	0.45	0.54	0.60	0.19	0.08
Hen-Dung (fresh)	1.63	1.98	0.85	1.54	0.24
Mixed Stable-Manure	0.50	0.60	0.63	0.26	0.70

General View of Fruit Department, Experiment Farm, Southern Pines, North Carolina.

PART III.

THE USE OF FERTILIZERS.

There is no way to tell, without experiment, what food constituents a soil lacks. The crops themselves give valuable suggestions. As a rule lack of nitrogen is indicated when plants are pale-green in color, or when there is small growth of leaf or stalk, other conditions being favorable. A bright, deep green color, with a vigorous growth of leaf or stalk, is, in case of most crops, a sign that nitrogen is not lacking, but does not necessarily indicate that more nitrogen could not be used to advantage. An excessive growth of leaf or stalk, accompanied by an imperfect bud, flower, and fruit development, indicates too much nitrogen for the potash and phosphoric acid present. When such crops as corn, cabbage, grass, potatoes, etc., have a luxuriant, healthful growth, an abundance of potash in the soil is indicated; also when fleshy fruits of fine flavor and texture can be successfully grown. On the contrary, when these plants fail of a luxuriant growth, or are very low grade in quality, it is a certain indication that potash is lacking. When a soil produces good, early maturing crops of grain, with plump and heavy kernels, phosphoric acid will not generally be found deficient in the soil.

In order to ascertain with greater certainty what food elements are lacking in the soil, the surest way is for each farmer to do some experimenting on his own soil and crops. Apply different kinds of fertilizing materials in different combinations, using, for example, potash compounds in one place, phosphoric acid compounds in another, nitrogenous materials in another. Then different combinations can be made on other portions of the crop. Some portions of the field can be left without application of any kind. The result can then be studied in the yield of crop. In carrying on such field tests, several difficulties may be met. The season may frequently be such as to interfere seriously with the favorable action of the fertilizing materials applied. Thus, a severe drought may counteract all other conditions and prevent a satisfactory yield. The difference of mechanical condition of the soil on the same farm or even in the same field may prevent a fair comparison of the action of different kinds of fertilizing materials and elements. But, notwithstanding such difficulties, valuable suggestions will be gained from an experimental study of one's soil through the behavior of the crops.

PREFERENCES SHOWN BY PLANTS FOR DIFFERENT FORMS OF FOOD.

It is a fact of great interest and importance that one form of a fertilizing constituent is preferred by some plants to the same constituent in another form. This preference is indicated by greater yield or better quality of product or by both. Thus, wheat seems to give better results when nitrogen is applied in the form of nitrate of soda than in any other form. The quality of tobacco is injured by potash in the form of muriate and, hence, only sulphate should be used for fertilizing purposes. The quality of sugar beets and of potatoes appears to be better when sulphate of potash is used.

HOW TO USE FERTILIZERS.

While the soil may contain certain quantities of fertilizer naturally, in most cases it will not pay to give serious attention to this source of fertilization. Farmyard manure, and similar refuse substance should always be used with hoed crops, in which case it is plowed under; otherwise it is best used as a top dressing. When plowed under, farm manures should be applied for fall plowing, unless the crop to be grown covers the entire growing season, as, for example, Indian corn. The fertilizer in such manures becomes available very slowly.

Nitrate of soda, when used alone, should always be applied to growing crops, and for quick effects. For young fruit trees or for vegetables, one or more applications may be made with benefit. Complete fertilizers usually have a small proportion of their nitrogen in the form of nitrate of soda, and the remainder in a less active form, so that by the time the nitrate of soda is utilized, the other nitrogenous products become effective.

Sulphate of ammonia is a quick-acting nitrogenous fertilizer, but should be used only when the soil has been lately limed. Dried-blood, dried-fish and other similar materials are less active than nitrate of soda, but more so than the nitrogen of farm manures. They are generally used in complete fertilizers, and are best plowed in, or drilled in at seeding time. All forms of potash are equally available, but should be applied as early in the season as possible; even fall applications are advisable, as there is little danger of loss through drainage. Lime also aids the effectiveness of potash salts. Phosphates in the form of "supers" or acid phosphates, are very quickly available, resembling nitrate of soda in this respect, though it is hardly advisable to make more than one application, early in the season or at planting time. All other forms of phosphates are best applied in the fall, or very early in the spring.

NEEDS OF DIFFERENT CROPS.

It is a well known fact that different crops need different quantities of nitrogen, potash and phosphoric acid compounds. If we know with a fair degree of accuracy how many pounds of nitrogen, potash and phosphoric acid a crop of any kind will remove from the soil, then we have fairly definite knowledge of the amounts of different forms of plant-food to apply to the soil to insure a crop. If we could not depend upon the soil to furnish any plant-food, then, we should use, at least, the amounts of fertilizing materials removed by one crop. In the following table, we give the number of pounds of nitrogen, phosphoric acid and potash used by different kinds of crops grown on one acre of land. In studying this table, we must keep in mind that the figures do not in every case represent the amount of plant-food removed from the soil. Thus, with clovers, beans, peas and other leguminous crops, a portion of the nitrogen is obtained from the air, and hence we have need to apply less nitrogen in the form of fertilizer than appears to be called for by the table. In the case of fruits, like apples, pears, plums, etc., it will be found safe often to apply larger quantities than the table calls for, because the figures in the table do not indicate the demands made by the tree in increasing its growth.

TABLE GIVING THE AMOUNTS OF FERTILIZER INGREDIENTS (NITROGEN, POTASH AND PHOSPHORIC ACID) CONTAINED IN THE CROP FROM ONE ACRE.

CROP.	*Yield.*	*Straw, etc.*	*Nitrogen.*	*Potash.*	*Phosphoric Acid.*
Apples	15 tons	......	39 lbs.	60 lbs.	30 lbs.
Barley	30 bu.	2,000 lbs.	57 "	51 "	17 "
Beans	30 "	2,700 "	75 "	53 "	30 "
Buckwheat	34 "	2,800 "	56 "	40 "	14 "
Cabbage	30 tons	......	200 "	270 "	70 "
*Clover, green	......	15 tons	130 "	140 "	40 "
Clover, dry	......	2 "	82 "	88 "	18 "
Corn	70 bu.	6,000 lbs.	83 "	55 "	48 "
Grapes	2 tons	7,000 "	32 "	39 "	11 "
Hops	600 lbs.	2,700 "	84 "	53 "	23 "
Mixed Hay	......	5,000 "	70 "	77 "	18 "
Oats	60 bu.	3,200 "	55 "	62 "	22 "
Onions	45,000 lbs.	......	72 "	72 "	37 "
Pears	16 tons	......	32 "	26 "	10 "
Peas	30 bu.	3,000 lbs.	108 "	52 "	33 "
Plums	8 tons	......	30 "	40 "	4 "
Potatoes	200 bu.	1,500 lbs.	46 "	74 "	21 "
Rye	30 "	4,250 "	51 "	45 "	26 "
Sugar Beets	15 tons	6,000 "	69 "	143 "	32 "
Timothy Hay	......	4,000 "	89 "	94 "	23 "
Tobacco	1,600 lbs.	1,400 " stems	76 "	200 "	16 "
Tomatoes	10 tons	......	32 "	54 "	20 "
Turnips	700 bu.	5 tons	80 "	180 "	52 "
Wheat	35 "	3,000 lbs.	59 "	31 "	24 "

*Crimson Clover.

The above table may safely be used in computing the probable draught on the soil for each of the crops mentioned. It must be understood, however, that for fruits, the demand for fertilizer for the annual wood growth, and for the leaves and pruned twigs is not included.

SHOWING EFFECT OF FERTILIZERS ON COW PEAS.—VINE IN RIGHT HAND, FROM UNFERTILIZED PORTION OF THE FIELD; VINE IN LEFT HAND, FROM FERTILIZED PART.

FROM EXPERIMENT FARM, SOUTHERN PINES, N. C.

PART IV.

MIXTURES FOR DIFFERENT CROPS.

In making fertilizer mixtures, it was first proposed to make the ingredients correspond to the analysis of the plant. This method was practiced for some time, but it was found that there was already in the soil more or less available plant-food and that fertilizing material was often applied where one or more constituents could be omitted or reduced in quantity. It was then suggested that soil analysis should form the basis of determining the needs of the soil for different crops, but this failed to produce satisfactory results. The formulas at present used by many have been based, in part, upon the composition of the plant, and, in part, upon actual field tests.

The amount of nitrogen called for by analysis of plants is generally reduced, because we can depend upon the soil to furnish a considerable amount. In case of leguminous crops, the amount of nitrogen which we need to supply can be reduced to a small fraction of what the plant will use, because such crops can draw their main supply of nitrogen from the air.

The amount of soluble phosphoric acid is ordinarily increased above what plant analysis calls for, because the solubility is more or less decreased after the fertilizer comes in contact with the soil.

The formulas given in the pages following have been drawn from such various sources as could be considered reliable. The materials which are given for use are assumed to have a fairly definite composition, and calculations are based on the following composition:

(1) Nitrate of soda, containing 16 per cent. of nitrogen.

(2) Dried-blood, containing 10 per cent. of nitrogen.

(3) Sulphate of ammonia, containing 20 per cent. of nitrogen.

(4) Bone-meal, containing 20 per cent. of total phosphoric acid (one half being calculated as available during first season of application) also containing 4 per cent. of nitrogen.

Whenever bone-meal is used in a mixture, allowance should be made for its nitrogen, and so much less of other forms of nitrogen materials used.

(5) Dissolved bone, containing 15 per cent. of available phosphoric acid, and 3 per cent. of nitrogen.

(6) Acid phosphate, containing 12 per cent. of available phosphoric acid.

(7) Muriate of potash, containing 50 per cent. of potash.

(8) Sulphate of potash, containing 50 per cent. of potash.

(9) Kainit, containing 12 to 13 per cent. of potash.

In the directions for making equivalent fertilizers, it will be noticed that under each head of nitrogen, potash, or phosphoric acid, three separate sources of supply are given. Any one of these three may be used, depending on the home supply or the state of the market, as each one supplies the same quantity of actual fertilizer; but it will be well to examine carefully the remarks given earlier in this book as to the fertilizer functions of the three chief fertilizer ingredients, and decide from the nature of the crop to be grown whether a quick-acting fertilizer is needed, or if a more slow-acting fertilizer is desirable. For crops growing throughout a long season, it is better to use a portion of the nitrogen from a quick-acting source like nitrate of soda and a portion from a slow-acting source, as tankage, dried-blood or bone-meal.

ALFALFA.

Use per acre from 400 to 800 pounds of the following fertilizer:

Nitrogen....................	1	per cent.
Available Phosphoric Acid..	8	"
Potash......................	10	"

Instead of the above, the following materials may be used, which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

	Pounds materials per acre.
Nitrogen.......	(1) 30 to 60 lbs. nitrate of soda, or
	(2) 25 to 50 " sulph. of ammo., or
	(3) 50 to 100 " dried-blood.
Available Phosphoric Acid	(1) 300 to 600 lbs. bone-meal, or
	(2) 200 to 400 " dissolved bone, or
	(3) 250 to 500 " acid phosphate.
Potash.........	(1) 80 to 160 lbs. muriate, or
	(2) 80 to 160 " sulphate, or
	(3) 325 to 650 " kainit.

Suggestions. Like clover, alfalfa needs only small applications of nitrogen, because it can obtain nitrogen from the air. A liberal supply of phosphoric acid and potash compounds needs to be applied from time to time, the application being made preferably in the fall or early winter. Lime needs to be present in the soil in liberal proportions. When deficient, it can be applied in the form of ground limestone, chalk or marl at the rate of one to three tons an acre, and preferably two or three years before sowing crop.

APPLES.

For an apple orchard, an annual top-dressing of 400 to 800 pounds is necessary of a fertilizer as follows:

Nitrogen..................	2	per cent.
Available Phosphoric Acid..	8	"
Potash....................	12	"

Instead of the above, the following materials may be used, which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

	Pounds materials per acre.
Nitrogen.......	(1) 50 to 100 lbs. nitrate of soda, or
	(2) 40 to 80 " sulph. of ammo., or
	(3) 80 to 160 " dried-blood.
Available Phosphoric Acid	(1) 300 to 600 lbs. bone-meal, or
	(2) 200 to 400 " dissolved bone, or
	(3) 250 to 500 " acid phosphate.
Potash.........	(1) 100 to 200 lbs. muriate, or
	(2) 100 to 200 " sulphate, or
	(3) 400 to 800 " kainit.

Suggestions. Excessive application of nitrogen compounds to apple orchards is to be avoided, because it favors rank growth of trees at the expense of fruit. Fruit trees in bearing require annual application of fertilizers for best results.

ASPARAGUS.

As a fertilizer, use per acre from 400 to 800 pounds of the following:

Nitrogen	5 per cent.
Available Phosphoric Acid	7 "
Potash	9 "

Instead of the above, the following materials may be used, which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

	Pounds materials per acre.
Nitrogen	(1) 120 to 240 lbs. nitrate of soda, or
	(2) 200 to 400 " dried-blood.
Available Phosphoric Acid	(1) 300 to 600 lbs. bone-meal, or
	(2) 200 to 400 " dissolved bone, or
	(3) 250 to 500 " acid phosphate.
Potash	(1) 70 to 140 lbs. muriate, or
	(2) 70 to 140 " sulphate, or
	(3) 300 to 600 " kainit.

Suggestions. Stable-manure may be applied every two or three years in the fall after removing plants, and also every year a dressing of phosphoric acid and potash. Nitrate of soda is applied to best advantage in the spring, just as the shoots begin to appear.

BARLEY.

Use per acre 500 to 1000 lbs. of a fertilizer as follows:

Nitrogen	4 per cent.
Available Phosphoric Acid	7 "
Potash	8 "

Instead of the above, the following materials may be used, which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

		Pounds materials per acre.
Nitrogen.......	(1)	75 to 150 lbs. nitrate of soda, or
	(2)	50 to 100 " sulph. of ammo., or
	(3)	125 to 250 " dried-blood.
Available Phosphoric Acid	(1)	200 to 400 lbs. bone-meal, or
	(2)	150 to 300 " dissolved bone, or
	(3)	175 to 350 " acid phosphate.
Potash....... ..	(1)	50 to 100 lbs. muriate, or
	(2)	50 to 100 " sulphate, or
	(3)	200 to 400 " kainit.

Suggestions. Excess of nitrogen as found in stable-manure is to be avoided, because the quality of the grain may be injured.

BEANS.

Use per acre 500 to 1000 pounds of the following:

Nitrogen..................	1 per cent.
Available Phosphoric Acid..	7 "
Potash.....................	9 "

Instead of the above, the following materials may be used, which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

		Pounds materials per acre.
Nitrogen.......	(1)	30 to 60 lbs. nitrate of soda, or
	(2)	25 to 50 " sulph. of ammo., or
	(3)	50 to 100 " dried-blood.
Available Phosphoric Acid	(1)	250 to 500 lbs. acid phosphate, or
	(2)	200 to 400 " dissolved bone, or
	(3)	300 to 600 " bone-meal.
Potash.........	(1)	70 to 140 lbs. muriate, or
	(2)	70 to 140 " sulphate, or
	(3)	300 to 600 " kainit.

Suggestions. The formula given above applies to beans grown for the seeds. When beans are grown to be eaten green, as for string beans, three or four times as much nitrogen should be applied, as for example, 100 to 200 pounds of nitrate of soda for one acre; this is applied preferably in three or four portions at different times rather than all at once. The extra application of nitrogen will develop the foliage and pods and retard ripening.

BEETS—GARDEN.

Use per acre from 500 to 1,000 pounds of a fertilizer analyzing as follows:

Nitrogen..................	5 per cent.
Available Phosphoric Acid..	6 "
Potash....................	9 "

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

	Pounds materials per acre.
Nitrogen.......	(1) 120 to 240 lbs. nitrate of soda, or (2) 100 to 200 " sulph. of ammo., or (3) 200 to 400 " dried-blood.
Available Phosphoric Acid	(1) 200 to 400 lbs. acid phosphate, or (2) 175 to 350 " dissolved bone, or (3) 250 to 500 " bone-meal.
Potash.........	(1) 70 to 140 lbs. muriate, or (2) 70 to 140 " sulphate, or (3) 300 to 600 " kainit.

Suggestions. When beets are grown for sugar, potash is preferably used in the form of sulphate. In growing beets for garden or feeding purposes, somewhat less nitrogen can be used.

BLACKBERRIES.

Use per acre 500 to 1,000 pounds of a fertilizer containing:

Nitrogen....................	3 per cent.
Available Phosphoric Acid..	6 "
Potash....................	8 "

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

	Pounds materials per acre.
Nitrogen.......	(1) 100 to 200 lbs. nitrate of soda, or
	(2) 75 to 150 " sulph. of ammo., or
	(3) 150 to 300 " dried-blood.
Available Phosphoric Acid	(1) 250 to 500 lbs. acid phosphate, or
	(2) 200 to 400 " dissolved bone, or
	(3) 300 to 600 " bone-meal.
Potash.........	(1) 80 to 160 lbs. muriate, or
	(2) 80 to 160 " sulphate, or
	(3) 300 to 600 " kainit.

BUCKWHEAT.

Use per acre 350 to 700 pounds of a fertilizer containing:

Nitrogen....................	4 per cent.
Available Phosphoric Acid..	8 "
Potash....................	9 "

Instead of the above, the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

		Pounds materials per acre.
Nitrogen.......	(1)	90 to 180 lbs. nitrate of soda, or
	(2)	75 to 150 " sulph. of ammo., or
	(3)	150 to 300 " dried-blood.
Available Phosphoric Acid	(1)	250 to 500 lbs. acid phosphate, or
	(2)	200 to 400 " dissolved bone, or
	(3)	300 to 600 " bone-meal.
Potash.........	(1)	70 to 140 lbs. muriate, or
	(2)	70 to 140 " sulphate, or
	(3)	300 to 600 " kainit.

CABBAGE.

Use per acre from 1,000 to 2,000 pounds of fertilizer containing:

Nitrogen..................	4 per cent.
Available Phosphoric Acid..	7 "
Potash....................	9 "

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

		Pounds materials per acre.
Nitrogen.......	(1)	250 to 500 lbs. nitrate of soda, or
	(2)	200 to 400 " sulph. of ammo., or
	(3)	400 to 800 " dried-blood.
Available Phosphoric Acid	(1)	600 to 1200 lbs. acid phosphate, or
	(2)	500 to 1000 " dissolved bone, or
	(3)	700 to 1400 " bone-meal.
Potash.........	(1)	180 to 360 lbs. muriate, or
	(2)	180 to 360 " sulphate, or
	(3)	700 to 1400 " kainit.

CARROTS.

Use per acre from 500 to 1000 pounds of a fertilizer containing:

Nitrogen..................	3 per cent:
Available Phosphoric Acid..	7 "
Potash....................	8 "

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively :

	Pounds materials per acre.
Nitrogen........	(1) 90 to 180 lbs. nitrate of soda, or
	(2) 75 to 150 " sulph. of ammo., or
	(3) 150 to 300 " dried-blood.
Available Phosphoric Acid	(1) 300 to 600 lbs. acid phosphate, or
	(2) 250 to 500 " dissolved bone, or
	(3) 350 to 700 " bone-meal.
Potash..........	(1) 80 to 160 lbs. muriate, or
	(2) 80 to 160 " sulphate, or
	(3) 300 to 600 " kainit.

Suggestions. When stable-manure is used, it is preferably applied to the land the preceding year.

CELERY.

Use per acre from 800 to 1600 pounds of a fertilizer containing :

Nitrogen..................	5 per cent.
Available Phosphoric Acid..	6 "
Potash....................	8 "

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively :

	Pounds materials per acre.
Nitrogen........	(1) 250 to 500 lbs. nitrate of soda, or
	(2) 200 to 400 " sulph. of ammo., or
	(3) 400 to 800 " dried-blood.

Pounds materials per acre.

Available Phosphoric Acid	(1) 400 to 800 lbs.	acid phosphate, or
	(2) 350 to 700 "	dissolved bone, or
	(3) 500 to 1000 "	bone-meal.
Potash.........	(1) 130 to 260 lbs.	muriate, or
	(2) 130 to 260 "	sulphate, or
	(3) 500 to 1000 "	kainit.

Suggestions. On muck soils the amount of nitrogen may be decreased and that of potash increased. The direct application of stable-manure has been found often to produce rusty celery.

CHERRIES.

The fertilizer application should be from 500 to 1000 pounds per acre, of a fertilizer containing:

Nitrogen..................	2 per cent.
Available Phosphoric Acid..	7 "
Potash....................	9 "

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

Pounds materials per acre.

Nitrogen.......	(1) 60 to 120 lbs.	nitrate of soda, or
	(2) 50 to 100 "	sulph. of ammo., or
	(3) 100 to 200 "	dried-blood.
Available Phosphoric Acid	(1) 300 to 600 lbs.	acid phosphate, or
	(2) 250 to 500 "	dissolved bone, or
	(3) 350 to 700 "	bone-meal.
Potash.........	(1) 90 to 180 lbs.	muriate, or
	(2) 90 to 180 "	sulphate, or
	(3) 350 to 700 "	kainit.

The application per tree, depending on whether light or heavy bearing may be expected, would be as follows:

	Pounds materials per tree.
Nitrogen.......	(1) ½ to 1 lb. nitrate of soda, or (2) ½ to 1 " sulph. of ammonia, or (3) 1 to 2 " dried-blood.
Available Phosphoric Acid	(1) 3 to 6 lbs. acid phosphate, or (2) 2½ to 5 " dissolved bone, or (3) 3½ to 7 " bone-meal.
Potash.........	(1) 1 to 2 lbs. muriate, or (2) 1 to 2 " sulphate, or (3) 3½ to 7 " kainit.

CLOVER.

Fertilizer for Clover, same as for Alfalfa.

CORN.

Use per acre 500 to 1000 pounds of a fertilizer containing:

Nitrogen	2 per cent.
Available Phosphoric Acid ..	7 "
Potash	6 "

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

	Pounds materials per acre.
Nitrogen.......	(1) 60 to 120 lbs. nitrate of soda, or (2) 50 to 100 " sulph. of ammo., or (3) 100 to 200 " dried-blood.
Available Phosphoric Acid	(1) 300 to 600 lbs. acid phosphate, or (2) 250 to 500 " dissolved bone, or (3) 350 to 700 " bone-meal.

Potash........	(1) 60 to 120 lbs. muriate, or (2). 60 to 120 " sulphate, or (3) 250 to 500 " kainit.

Suggestions. The nitrogen may be applied to advantage in the form of stable-manure, especially if the soil is at all lacking in humus. For sweet corn, somewhat larger amounts of nitrogen may be applied.

CUCUMBERS

Use at the rate of 750 to 1500 pounds per acre of the following fertilizer:

Nitrogen....................	4 per cent.
Available Phosphoric Acid ..	6 "
Potash.....................	8 "

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

	Pounds materials per acre.
Nitrogen........	(1) 180 to 360 lbs. nitrate of soda, or (2) 150 to 300 " sulph. of ammo., or (3) 300 to 600 " dried-blood.
Available Phosphoric Acid	(1) 400 to 800 lbs. acid phosphate, or (2) 350 to 700 " dissolved bone, or (3) 500 to 1000 " bone-meal.
Potash..........	(1) 130 to 260 lbs. muriate, or (2) 130 to 260 " sulphate, or (3) 500 to 1000 " kainit.

Suggestions. Too much nitrogen is to be avoided, as there will be a tendency to excessive growth of vines, and the fruit will be less firm and more likely to decay. Sulphate of ammonia will often give better results than the more quickly acting nitrate of soda, as the period of growth will be longer and the yield larger. Stable-manure, when used, is preferably applied in fall, followed by sulphate of ammonia in the spring. The phosphoric acid may be applied, one-half in the fall and the rest in the spring.

CURRANTS.

Use per acre 500 to 1000 pounds of a fertilizer containing:

Nitrogen..................	2 per cent,
Available Phosphoric Acid..	5 "
Potash....................	8 "

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

		Pounds materials per acre.
Nitrogen.......	(1)	60 to 120 lbs. nitrate of soda, or
	(2)	50 to 100 " sulph. of ammo., or
	(3)	100 to 200 " dried-blood.
Available Phosphoric Acid	(1)	200 to 400 lbs. acid phosphate, or
	(2)	175 to 350 " dissolved bone, or
	(3)	250 to 500 " bone-meal.
Potash.........	(1)	80 to 160 lbs. muriate, or
	(2)	80 to 160 " sulphate, or
	(3)	320 to 640 " kainit.

EGG PLANTS.

Use per acre 1,000 to 2,000 pounds of a fertilizer, containing:

Nitrogen..................	4 per cent.
Available Phosphoric Acid..	5 "
Potash....................	9 "

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

		Pounds materials per acre.
Nitrogen.......	(1)	240 to 480 lbs. nitrate of soda, or
	(2)	200 to 400 " sulph. of ammo., or
	(3)	400 to 800 " dried-blood.
Available Phosphoric Acid	(1)	400 to 800 lbs. acid phosphate, or
	(2)	350 to 700 " dissolved bone, or
	(3)	500 to 1000 " bone-meal.
Potash..........	(1)	180 to 360 lbs. muriate, or
	(2)	180 to 360 " sulphate, or
	(3)	700 to 1400 " kainit.

FLAX.

Use per acre 325 to 650 pounds of a fertilizer containing:

Nitrogen....................	3 per cent.
Available Phosphoric Acid..	8 "
Potash.....................	9 "

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

		Pounds materials per acre.
Nitrogen........	(1)	60 to 120 lbs. nitrate of soda, or
	(2)	50 to 100 " sulph. of ammo., or
	(3)	100 to 200 " dried-blood.
Available Phosphoric Acid	(1)	200 to 400 lbs. acid phosphate, or
	(2)	175 to 350 " dissolved bone, or
	(3)	250 to 500 " bone-meal.
Potash..........	(1)	60 to 120 lbs. muriate, or
	(2)	60 to 120 " sulphate, or
	(3)	250 to 500 " kainit.

GOOSEBERRIES.

Fertilizer for Gooseberries, same as for Currants.

GRAPES.

Use per acre from 400 to 800 pounds of the following fertilizer:

Nitrogen....................	2	per cent.
Available Phosphoric Acid..	8	"
Potash.....................	11	"

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

Grapes, unfertilized.—Experiment Farm, Southern Pines, N. C.

GRAPES, WITH MEDIUM FERTILIZATION.—EXPERIMENT FARM. SOUTHERN PINES, N. C.

GRAPES, WITH HEAVY FERTILIZATION—EXPERIMENT FARM, SOUTHERN PINES, N. C.

		Pounds materials per acre.
Nitrogen........	(1)	50 to 100 lbs. nitrate of soda, or
	(2)	40 to 80 " sulph. of ammo., or
	(3)	80 to 160 " dried-blood.
Available Phosphoric Acid	(1)	250 to 500 lbs. acid phosphate, or
	(2)	200 to 400 " dissolved bone, or
	(3)	300 to 600 " bone-meal.
Potash..........	(1)	90 to 180 lbs. muriate, or
	(2)	90 to 180 " sulphate, or
	(3)	350 to 700 " kainit.

Suggestions. Much of the nitrogen can be supplied by growing clover between the rows and turning under. Excessive use of stable-manure is believed to produce a growth of weakened vitality, not able readily to withstand attacks of fungous diseases. Once in a few years, lime may be applied to advantage.

GRASS FOR PASTURES.

Use per acre from 750 to 1,500 pounds of the following fertilizer :

Nitrogen....................	2 per cent.
Available Phosphoric Acid..	8 "
Potash.....................	10 "

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively :

		Pounds materials per acre.
Nitrogen........	(1)	90 to 180 lbs. nitrate of soda, or
	(2)	75 to 150 " sulph. of ammo., or
	(3)	150 to 300 " dried-blood.
Available Phosphoric Acid	(1)	250 to 500 lbs. acid phosphate, or
	(2)	200 to 400 " dissolved bone, or
	(3)	300 to 600 " bone-meal.

Potash	(1) 80 to 160 lbs.	muriate, or
	(2) 80 to 160 "	sulphate, or
	(3) 275 to 550 "	kainit.

Suggestions. It is probable that the droppings from animals will furnish most of the nitrogen needed, but pains should be taken occasionally to run some kind of smoothing harrow over the ground to distribute the droppings evenly.

GRASS FOR LAWNS.

Use 400 to 800 pounds per acre of the following fertilizer:

Nitrogen	5 per cent.
Available Phosphoric Acid	6 "
Potash	8 "

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

		Pounds materials per acre.
Nitrogen	(1) 120 to 240 lbs.	nitrate of soda, or
	(2) 100 to 200 "	sulph. of ammo., or
	(3) 200 to 400 "	dried-blood.
Available Phosphoric Acid	(1) 200 to 400 lbs.	acid phosphate, or
	(2) 175 to 350 "	dissolved bone, or
	(3) 250 to 500 "	bone-meal.
Potash	(1) 60 to 120 lbs.	muriate, or
	(2) 60 to 120 "	sulphate, or
	(3) 250 to 500 "	kainit.

Suggestions. As a more specific mixture, we suggest the following: 100 lbs, nitrate of soda, 100 lbs. bone-meal, 100 lbs. acid phosphate, and 100 lbs. muriate of potash per acre.

GRASS FOR MEADOWS.

Use from 375 to 750 lbs. per acre of the following fertilizer:

Nitrogen....................	4 per cent.
Available Phosphoric Acid..	7 "
Potash......................	9 "

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

		Pounds materials per acre.
Nitrogen........	(1)	90 to 180 lbs. nitrate of soda, or
	(2)	75 to 150 " sulph. of ammo., or
	(3)	150 to 300 " dried-blood.
Available Phosphoric Acid	(1)	250 to 500 lbs. acid phosphate, or
	(2)	200 to 400 " dissolved bone, or
	(3)	300 to 600 " bone-meal.
Potash..........	(1)	70 to 140 lbs. muriate, or
	(2)	70 to 140 " sulphate, or
	(3)	275 to 550 " kainit.

Suggestions. The fact cannot be too strongly emphasized that meadows from which grass is cut year after year should be regularly fertilized every year in a liberal manner.

HOPS.

Use per acre 650 to 1,300 pounds of a fertilizer containing:

Nitrogen....................	3 per cent.
Available Phosphoric Acid...	6 "
Potash......................	12 "

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

	Pounds materials per acre.
Nitrogen........	(1) 120 to 240 lbs. nitrate of soda, or (2) 100 to 200 " sulph. of ammo., or (3) 200 to 400 " dried-blood.
Available Phosphoric Acid	(1) 275 to 550 lbs. acid phosphate, or (2) 250 to 500 " dissolved bone, or (3) 350 to 700 " bone-meal.
Potash........	(1) 200 to 400 lbs. muriate, or (2) 200 to 400 " sulphate, or (3) 800 to 1600 " kainit.

LETTUCE.

Use per acre 800 to 1,600 pounds of a fertilizer containing:

Nitrogen....................	5 per cent.
Available Phosphoric Acid..	6 "
Potash.....................	9 "

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

	Pounds materials per acre.
Nitrogen........	(1) 250 to 500 lbs. nitrate of soda, or (2) 200 to 400 " sulph. of ammo, or (3) 400 to 800 " dried-blood.
Available Phosphoric Acid	(1) 400 to 800 lbs. acid phosphate, or (2) 350 to 700 " dissolved bone, or (3) 500 to 1000 " bone-meal.
Potash..........	(1) 150 to 300 lbs. muriate, or (2) 150 to 300 " sulphate, or (3) 600 to 1200 " kainit.

Suggestions. When lettuce is grown under glass, use about half as much nitrogen and a half more phosphoric acid and potash than indicated above.

LUCERNE.

Fertilizer for Lucerne, same as for Alfalfa.

NURSERY STOCK.

Use per acre 325 to 650 pounds of the following fertilizer:

Nitrogen	3 per cent.
Available Phosphoric Acid	6 "
Potash	7 "

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively.

Pounds materials per acre.

Nitrogen	(1)	60 to 120 lbs. nitrate of soda, or
	(2)	50 to 100 " sulph. of ammo., or
	(3)	100 to 200 " dried-blood.
Available Phosphoric Acid	(1)	200 to 400 lbs. acid phosphate, or
	(2)	175 to 350 " dissolved bone, or
	(3)	250 to 500 " bone-meal.
Potash	(1)	60 to 120 lbs. muriate, or
	(2)	60 to 120 " sulphate, or
	(3)	240 to 480 " kainit.

Suggestions. Excess of nitrogen produces a rapid but weak growth of wood.

OATS.

On average soils, it would be best to give oats 300 to 600 pounds per acre of a fertilizer containing:

Nitrogen	4 per cent.
Available Phosphoric Acid	6 "
Potash	9 "

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

		Pounds materials per acre.
Nitrogen........	(1)	75 to 150 lbs. nitrate of soda, or
	(2)	60 to 120 " sulph. of ammo., or
	(3)	120 to 240 " dried-blood.
Available Phosphoric Acid	(1)	160 to 320 lbs. acid phosphate, or
	(2)	140 to 280 " dissolved bone, or
	(3)	200 to 400 " bone-meal.
Potash..........	(1)	60 to 120 lbs. muriate, or
	(2)	60 to 120 " sulphate, or
	(3)	250 to 500 " kainit.

ONIONS.

Use per acre 900 to 1,800 pounds of a fertilizer containing:

Nitrogen.........	5 per cent.
Available Phosphoric Acid..	6 "
Potash....................	9 "

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

		Pounds materials per acre.
Nitrogen........	(1)	270 to 540 lbs. nitrate of soda, or
	(2)	225 to 450 " sulph. of ammo., or
	(3)	450 to 900 " dried-blood.
Available Phosphoric Acid	(1)	450 to 900 lbs. acid phosphate, or
	(2)	385 to 770 " dissolved bone, or
	(3)	550 to 1100 " bone-meal.
Potash..........	(1)	160 to 320 lbs. muriate, or
	(2)	160 to 320 " sulphate, or
	(3)	650 to 1300 " kainit.

Suggestions. Fresh stable-manure is to be avoided on account of weed-seeds and also a tendency to favor the growth of onion-maggots. Stable-manure is preferably used in soil two years before planting onions. An excess of nitrogen delays the ripening and injures the keeping qualities of the onions.

PARSNIPS.

Use per acre 650 to 1,300 pounds of a fertilizer as follows:

Nitrogen....................	3 per cent.
Available Phosphoric Acid..	9 "
Potash......................	8 "

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively.

	Pounds materials per acre.
Nitrogen........	(1) 120 to 240 lbs. nitrate of soda, or
	(2) 100 to 200 " sulph. of ammo., or
	(3) 200 to 400 " dried-blood.
Available Phosphoric Acid	(1) 450 to 900 lbs. acid phosphate, or
	(2) 375 to 750 " dissolved bone, or
	(3) 550 to 1100 " bone-meal.
Potash..........	(1) 100 to 200 lbs. muriate, or
	(2) 100 to 200 " sulphate, or
	(3) 400 to 800 " kainit.

Suggestions. Stable-manure, when used, is preferably applied the preceding year.

PEACHES.

Use 750 to 1500 pounds per acre of a fertilizer containing:

Nitrogen	2 per cent.	
Available Phosphoric Acid	5	"
Potash	7	"

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

		Pounds materials per acre.
Nitrogen	(1)	90 to 180 lbs. nitrate of soda, or
	(2)	75 to 150 " sulph. of ammo., or
	(3)	150 to 300 " dried-blood.
Available Phosphoric Acid	(1)	320 to 640 lbs. acid phosphate, or
	(2)	280 to 560 " dissolved bone, or
	(3)	400 to 800 " bone-meal.
Potash	(1)	110 to 220 lbs. muriate, or
	(2)	110 to 220 " sulphate, or
	(3)	450 to 900 " kainit.

Suggestions. Much of the nitrogen may be furnished by raising leguminous crops between the rows of trees and turning under for green-manure. It is claimed that large applications of potash enable the trees more readily to withstand the disease known as "Peach Yellows."

PEARS.

Fertilizer for Pears, same as for Apples.

PEAS.

Fertilizer for Peas, same as for Beans.

Suggestions. When peas are raised for picking green, larger amounts of nitrate of soda may be used to advantage.

PLUMS.

Fertilizer for Plums, same as for Cherries.

Peaches.—Unfertilized.

Peaches.—Fertilized with Potash, Phosphoric Acid and Nitrogen.
Experiment Farm, Southern Pines, N. C.

POTATOES (Sweet or White)

For general purposes use per acre 750 to 1500 pounds of a fertilizer containing:

Nitrogen	4 per cent.
Available Phosphoric Acid ..	6 "
Potash	9 "

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

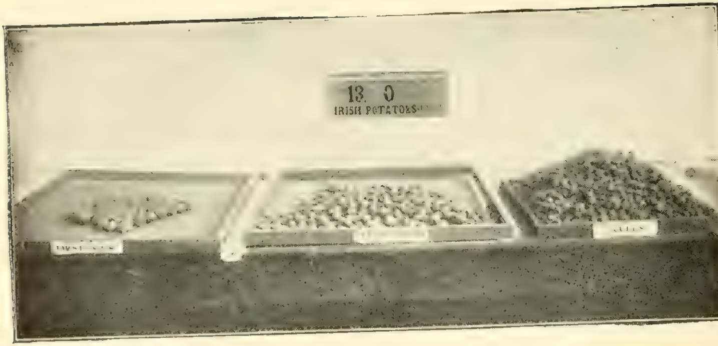
Pounds materials per acre.

Nitrogen........	(1)	180 to 360 lbs. nitrate of soda, or
	(2)	150 to 300 " sulph. of ammo., or
	(3)	300 to 600 " dried-blood.
Available Phosphoric Acid	(1)	325 to 650 lbs. acid phosphate, or
	(2)	275 to 550 " dissolved bone, or
	(3)	400 to 800 " bone-meal.
Potash.	(1)	130 to 260 lbs. muriate, or
	(2)	130 to 260 " sulphate, or
	(3)	520 to 1040 " kainit.

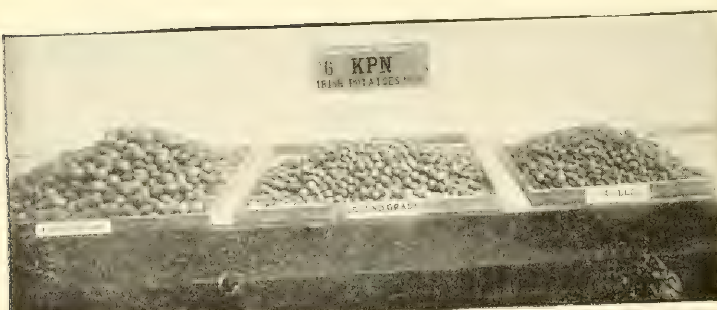
Suggestions. The use of stable-manure appears to favor the growth of potato-scab. When used, stable-manure should be applied to a preceding crop. Wood-ashes are also reported to favor the attack of the scab. It is commonly held that sulphate of potash produces potatoes of better quality than does muriate. The testimony on this point is conflicting.

RADISHES.

A good fertilizer for radishes per acre is 500 to 1,000 pounds of the following mixture:



Potatoes.—Unfertilized. Experiment Farm, Southern Pines, N. C.



Potatoes.—Fertilized with Potash, Phosphoric Acid and Nitrogen. Experiment Farm, Southern Pines, N. C.

SWEET POTATOES,—UNFERTILIZED. EXPERIMENT FARM, SOUTHERN PINES, N. C.

SWEET POTATOES.—FERTILIZED WITH POTASH, PHOSPHORIC ACID AND NITROGEN. EXPERIMENT FARM, SOUTHERN PINES, N. C.

Nitrogen....................	3 per cent.
Available Phosphoric Acid..	7 "
Potash.....................	9 "

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

		Pounds materials per acre.
Nitrogen........	(1)	90 to 180 lbs. nitrate of soda, or
	(2)	75 to 150 " sulph. of ammo., or
	(3)	150 to 300 " dried-blood.
Available Phosphoric Acid	(1)	280 to 560 lbs. acid phosphate, or
	(2)	250 to 500 " dissolved bone, or
	(3)	350 to 700 " bone-meal.
Potash..........	(1)	90 to 180 lbs. muriate, or
	(2)	90 to 180 " sulphate, or
	(3)	350 to 700 " kainit.

RASPBERRIES.

Use 600 to 1,200 pounds per acre of a fertilizer containing:

Nitrogen....................	2 per cent.
Available Phosphoric Acid...	7 "
Potash.....................	10 "

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

		Pounds materials per acre.
Nitrogen........	(1)	75 to 150 lbs. nitrate of soda, or
	(2)	60 to 120 " sulph. of ammo., or
	(3)	120 to 240 " dried-blood.
Available Phosphoric Acid	(1)	320 to 640 lbs. acid phosphate, or
	(2)	280 to 560 " dissolved bone, or
	(3)	400 to 800 " bone-meal.

Pounds materials per acre.

Potash..........	(1) 120 to 240 lbs. muriate, or (2) 120 to 240 " sulphate, or (3) 480 to 960 " kainit.

RYE.

Fertilizer for Rye, same as for Oats.

Suggestions. Nitrogen is preferable in the form of nitrate of soda rather than stable-manure. Excessive use of nitrogen should be avoided.

SORGHUM.

Fertilizer for Sorghum, same as for Corn.

SPINACH.

Use per acre 750 to 1,500 pounds of a fertilizer containing:

Nitrogen....................	2 per cent.
Available Phosphoric Acid..	7 "
Potash......................	5 "

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

Pounds materials per acre.

Nitrogen........	(1) 90 to 180 lbs. nitrate of soda, or (2) 75 to 150 " sulph. of ammo., or (3) 150 to 300 " dried-blood.
Available Phosphoric Acid	(1) 450 to 900 lbs. acid phosphate, or (2) 375 to 750 " dissolved bone, or (3) 550 to 1100 " bone-meal.
Potash..........	(1) 80 to 160 lbs. muriate, or (2) 80 to 160 " sulphate, or (3) 320 to 640 " kainit.

SQUASHES.

Fertilizer for Squashes, same as for Cucumbers.

STRAWBERRIES.

Apply per acre 825 to 1650 pounds of a fertilizer containing:

Nitrogen....................	3	per cent.
Available Phosphoric Acid..	7	"
Potash......................	9	"

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

	Pounds materials per acre.
Nitrogen........	(1) 150 to 300 lbs. nitrate of soda, or
	(2) 125 to 250 " sulph. of ammo., or
	(3) 250 to 500 " dried-blood.
Available Phosphoric Acid	(1) 450 to 900 lbs. acid phosphate, or
	(2) 375 to 750 " dissolved bone, or
	(3) 550 to 1100 " bone-meal.
Potash..........	(1) 140 to 280 lbs. muriate, or
	(2) 140 to 280 " sulphate, or
	(3) 550 to 1100 " kainit.

TOBACCO.

Use per acre 750 to 1,500 pounds of a fertilizer containing:

Nitrogen....................	4	per cent.
Available Phosphoric Acid..	6	"
Potash......................	10	"

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

	Pounds materials per acre.
Nitrogen........	(1) 180 to 360 lbs. nitrate of soda, or (2) 150 to 300 " sulph. of ammo., or (3) 300 to 600 " dried-blood.
Available Phosphoric Acid	(1) 400 to 800 lbs. acid phosphate, or (2) 350 to 700 " dissolved bone, or (3) 500 to 1000 " bone-meal.
Potash..........	(1) 160 to 320 lbs. sulphate, or (2) 320 to 640 " sulphate of potash-magnesia.

Suggestions. Stable-manure may advantageously be applied to the preceding crop. Potash should be used only in form of sulphate.

TOMATOES.

On an acre use 625 to 1,250 pounds of a fertilizer containing:

Nitrogen....................	4 per cent.
Available Phosphoric Acid..	6 "
Potash.....................	7 "

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

	Pounds materials per acre.
Nitrogen........	(1) 150 to 300 lbs. nitrate of soda, or (2) 125 to 250 " sulph. of ammo., or (3) 250 to 500 " dried-blood.
Available Phosphoric Acid	(1) 280 to 560 lbs. acid phosphate, or (2) 250 to 500 " dissolved bone, or (3) 350 to 700 " bone-meal.
Potash..........	(1) 80 to 160 lbs. muriate, or (2) 80 to 160 " sulphate, or (3) 320 to 640 " kainit.

Tobacco Unfertilized.

Tobacco Fertilized with Potash, Phosphoric Acid and Nitrogen.
Experiment Farm, Southern Pines N. C.

TURNIPS.

Fertilizer for Turnips, same as for Beets.

VETCH.

Fertilizer for Vetch, same as for Cow Peas.

WATERMELONS.

Fertilizer for Watermelons, same as for Cucumbers

WHEAT.

Use per acre 300 to 600 pounds of a fertilizer containing:

Nitrogen	4	per cent.
Available Phosphoric Acid	7	"
Potash	4	"

Instead of the above the following materials may be used which will furnish equivalent quantities of nitrogen, phosphoric acid and potash respectively:

		Pounds materials per acre.
Nitrogen	(1)	75 to 150 lbs. nitrate of soda, or
	(2)	60 to 120 " sulph. of ammo., or
	(3)	120 to 240 " dried-blood.
Available Phosphoric Acid	(1)	160 to 320 lbs. acid phosphate, or
	(2)	140 to 280 " dissolved bone, or
	(3)	200 to 400 " bone-meal.
Potash	(1)	25 to 50 lbs. muriate, or
	(2)	25 to 50 " sulphate, or
	(3)	100 to 200 " kainit.

SUGGESTIONS RELATING TO SEPARATE FERTILIZING INGREDIENTS.

It will generally be found more economical to purchase fertilizing materials of high grade. In applying fertilizers, bulk is often desirable, but in purchasing commercial fertilizers, the object should be to secure as much nitrogen, potash and phosphoric acid in available forms as possible for one dollar, instead of as many pounds as possible of fertilizers, regardless of the amount of plant food contained in it. This is particularly applicable to mixed fertilizers. Since there is a smaller bulk to handle in mixing, a smaller number of packages for holding and, consequently, less weight and freight, it is, as a rule, more economical to purchase fertilizers in their more concentrated forms. For illustration, it is more economical to purchase one ton of a high-grade fertilizer than three tons of a low-grade fertilizer, one ton of the former containing the same amount of plant-food contained in three tons of the latter; because, in making the latter, three times as many packages are required and three times as much freight must be paid all for the same amount of plant-food.

Fertilizers cannot, as a rule, be in too finely powdered condition, nor can they be too dry. With many materials, bone for example, the availability as plant-food is directly dependent upon the fineness of division. Excessive moisture in fertilizer is undesirable on several grounds. First, the larger the amount of moisture, the smaller will be the amount of plant-food in a ton. Second, excess of moisture causes the particles to stick together, and is likely to result in caking and clogging when used in drills. Third, an excess of moisture favors the decomposition and loss of nitrogen in many forms of organic matter. This is shown by the fact that some fertilizers give off a very offensive odor if allowed to become damp, while they are comparatively free from disagreeable odors if they are thoroughly dry. A strong odor in a fertilizer is an indication that organic matter is decomposing and nitrogen is being lost.

METHODS AND SEASONS OF APPLYING FERTILIZERS.

The effect of a fertilizer is lost if it does not reach the plant roots. Pains must be taken to secure even and complete distribution of fertilizers on or in the soil, since it is desired to have the food reach every plant in the field. In order to distribute small quantities of concentrated fertilizers over a broad area, it is well to dilute by mixing with some such substance as dry earth, road-dust, sifted coal-ashes or sand.

As between applying fertilizers with the drill or by broadcasting, the best results are given sometimes by one and sometimes by the other method, according to circumstances. When a fertilizer is especially needed by a crop in its earliest stages, there is advantage in drilling it in with the seed. When concentrated fertilizers are to be distributed broadcast, it is desirable that they should be somewhat diluted.

Materials which are readily soluble can be scattered over the surface. After the first fall of rain they distribute themselves throughout the soil very completely and uniformly. Such materials are nitrate of soda, sulphate of ammonia, soluble phosphates, and soluble potash salts. These materials are preferably used in case of top dressings.

Materials which are not readily soluble are preferably well mixed through and beneath the soil. Thus, dried-blood, bone-meal, fish-scrap, and similar materials are best placed at greater depth beneath the soil, because under these conditions they become soluble more rapidly and are retained more surely by the soil.

Time of application. Fertilizers which dissolve easily and diffuse through soil rapidly and which are not readily retained by the soil, are best applied only when the crop is ready to utilize them. If put on too early, there is danger of their being leached from the soil and carried more or less beyond the reach of the plant, and thus lost. Nitrate, and to a less extent, ammonia compounds, come under this precaution. Hence it is not wise ordinarily to apply guano, ammonia compounds or nitrate of soda in the fall, except in climates which have a dry fall and winter. Their application should be deferred until spring. In wet spring, ammonia compounds are preferably applied rather than nitrate of soda ; or, if nitrate of soda is used, loss may be avoided by making several small applications instead of one at the start. Care should be taken, however, not to make applications of nitrate of soda too late in the season, as the maturing of the crop will be retarded and there will be an excessive growth of stems and leaves.

Fertilizers which do not dissolve readily or which do not diffuse through the soil rapidly are better applied to the land before the crop commences its growth. To this class belong stable-manure, bone-manure, dried-blood, tankage, cotton-seed-meal, ground-rock, and, to some extent, soluble phosphates and potash compounds.

In applying highly concentrated commercial fertilizers, it is wise to prevent the fertilizer coming in contact with the seeds or foliage of plants. Fertilizers containing ammonia compounds should not be mixed with wood-ashes, lime, or Thomas slag (odorless phosphate), since some of the ammonia is likely to be lost.

On soils of loose texture and small retentive power, it is best to use, for the most part, those forms of fertilizers which are not too easily soluble, in order to make as small as possible the losses occasioned by heavy rains. Animal and vegetable materials are specially suited for such cases.

In order to use farm-yard manures to the best advantage on the average soil, we need to supplement them with commercial fertilizers containing available phosphoric acid and potash. To give a roughly approximate idea, we might say that for every ton of stable-manure applied, it would be well to use with it from 50 to 100 pounds of acid phosphate and from 25 to 50 pounds of high-grade muriate or sulphate of potash. It appears to be the prevailing belief both in theory and practice that best results are ordinarily secured by applying stable-manure to the soil in as fresh condition as possible. Fresh manure gives better results than rotted manure on heavy clay soils, when one desires to lighten the condition of the soil. However, when one desires direct fertilizing action promptly, fresh manure gives sufficiently quick returns on light soils, becoming available as fast as the plant needs it, if the season is not too dry. On heavy clay soils, manure decomposes slowly and the constituents of fresh manure may not become available as fast as needed.

Fresh manure has a tendency to favor rapid growth of foliage and stems at the expense of the fruit and grain. It is, therefore more suitable for grasses, forage plants and leafy crops than for grains. Such crops as potatoes, sugar-beets and tobacco appear to be injured in quality by the direct application of stable-manure. It is advised in such cases to apply the manure in the fall previous to the spring in which the crops are to be put in, thus allowing time for a considerable amount of decomposition.

In rotted manure, the fertilizing constituents, as a rule, are in readily available form for the use of plants. Such manure is less bulky and more easily distributed than fresh manure. It is also less likely to promote the too rapid growth of stems and leaves as in the case of fresh manure. For the improvement of the mechanical condition of a soil, the best results come from using rotted manure on light soils. It must, however, be remembered that on such soils there is more or less danger that some portion of the valuable fertilizing constituents may be leached out and lost. On this account it is found advisable to apply such manure to light soils only a short time before it is needed by the crop. In general, rotted manure is better adapted to spring applications. It is better to apply rotted manure on light soils at frequent intervals in small amounts. In warm, moist climates, it makes much less difference whether the manure is applied in fresh or rotted condition. In cold climates, however, the use of decomposed manure is preferable.

Three methods of applying manure on the field are in common practice.

Applying in Heaps. By this method the manure is distributed in heaps over the field and permitted to lie some time before being spread. This method is objectionable for several reasons. The labor of handling is increased ; there is danger from loss of decomposition and leaching ; the manure is not uniformly distributed, the spots beneath the heaps being more thoroughly manured on account of the leaching. Storing manure in very large heaps is less objectionable, provided the heap is carefully covered with earth and not allowed to lie too long.

Applying Broadcast. By this method the manure is spread more or less completely and evenly on the field, being plowed in at once or allowed to lie some time on the surface. This is preferably practiced on the level field, where there is little danger from surface washing. In late fall and early spring, there is likely to be very little loss of nitrogen. On a loose soil, there may be loss from leaching, if the manure is spread long before the crop is put into the soil ; but in average experience this is not apt to be considerable. This method has the advantage of uniform distribution as the liquid portion is evenly by degrees mixed with the soil. When manure is leached of its soluble nitrogen compounds, it does not decompose so readily. On this account, it is well, in case of light or porous soils, to plow the manure in as soon as spread. In regard to the depth in which manure should be plowed in, it is safe to say that in very compact soils, the depth should not be greater than four inches, while in lighter soils the depth may be increased. It is important that the manure be near enough the surface to allow access of sufficient moisture and air, in order that decomposition may not be too much delayed.

Applying in Rows. This method has the advantage of placing the manure where it will reach the plant most quickly and enabling one to use smaller amounts than in broadcasting. It is especially applicable for forcing some garden crops. Rotted manure gives good results when used this way.

RULES FOR CALCULATING FROM ONE COMPOUND INTO OTHER COMPOUNDS.

Compounds Containing Nitrogen.

To change ammonia into an equivalent amount of nitrogen, multiply the amount of ammonia by 0.82.

To change nitrogen into an equivalent amount of ammonia, multiply the amount of nitrogen by 1 .21.

To change nitrate of soda into an equivalent amount of ammonia, divide the amount of nitrate of soda by 5.

To change nitrate of soda into an equivalent amount of nitrogen, divide the amount of nitrate of soda by 6.

To change nitrogen into an equivalent amount of nitrate of soda, multiply the nitrogen by 6.

To change sulphate of ammonia into an equivalent amount of ammonia, divide the amount of pure sulphate of ammonia by 4.

To change ammonia into an equivalent amount of sulphate of ammonia, multiply the amount of ammonia by 3.9.

To change nitrate of potash into an equivalent amount of nitrogen, divide the amount of nitrate of potash by 7.2.

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