New York Agricultural Experiment Station.

PETER COLLIER, DIRECTOR.

BULLETIN No. 27—NEW SERIES.
FEBRUARY, 1891.

THE NEW YORK STATE FERTILIZER CONTROL AND FERTILIZER ANALYSES.

III. GENERAL PRINCIPLES UNDERLYING THE USE OF FERTILIZERS.

GENEVA, N. Y.

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The Bulletins published by the Station will be sent free to any farmer applying for them.

*Connected with Fertilizer Control.

NOTICE.

These fertilizer bulletins are intended to explain such facts as will make farmers familiar with the different terms used to express the composition of fertilizers, and also to enable them to understand some of the more general principles involved in the use of fertilizers, together with such other information as it is thought farmers would like to know.

In order that an attempt may be made to cover all points, about which information is desired, farmers are urged to send to the Station any inquiries in this line, in regard to which they desire specific information.

By consulting Bulletin No. 25, page 350, the topics to be treated and the general outline to be followed can be found.

This series of Bulletins is issued for the benefit of the farmers of New York State. As each bulletin will be a continuation of the preceding one, it will be well for those interested to preserve the early issues for future reference.

These and all other bulletins issued by the Station will be mailed to any citizen of New York State, on application.

BULLETIN No. 27, NEW SERIES.

THE NEW YORK STATE FERTILIZER CONTROL

AND

FERTILIZER ANALYSES.

Following is an outline of the contents of this Bulletin:

III. Principles underlying the use of fertilizers (concluded).

(9). Phosphorus.

(*a*) Description; (*b*) Occurrence; (*c*) Importance; (*d*) Specific action upon plants; (*e*) Different kinds of calcium phosphate; (*f*) Relations of phosphates to fertilizers; (*g*) Phosphates not lost to soil.

(10). Sulphur.

(*a*) Occurrence; (*b*) Sulphuric acid and sulphates; (*c*) Relations of sulphur compounds to fertilizers.

(11). Chlorine.

(*a*) Description and occurrence in nature.

(12). Silicon.

(*a*) Occurrence in nature.

(13). Calcium.

(*a*) Occurrence in nature and compounds; (*b*) Relations of calcium compounds to fertilizers; (*c*) Sulphate of lime as an indirect fertilizer; (*d*) Quick-lime as an indirect fertilizer.

(14). Potassium.

(*a*) Occurrence and compounds; (*b*) Relations of potassium compounds to fertilizers.

(15). Sodium.

(*a*) Occurrence in nature.

(16). Magnesium, iron, and manganese.

(17). The most important elements of plant food in relation to fertilizers.

3. Constituents of soils.

(*a*) General composition and origin of soils; (*b*) Food constituents and mechanical constituents; (*c*) Analysis of soils; (*d*) How to find out the needs of a soil.

4. Relations of plants and soils.

PHOSPHORUS.

46. Description of Phosphorus.—Phosphorus, when uncombined with other elements, is a yellowish, waxy looking, solid substance. It is soft and can be cut as easily as ordinary beeswax. It is very poisonous. It takes fire very easily and, therefore, has to be kept under water. When phosphorus burns, it simply unites with the oxygen of the air, forming a compound which contains oxygen and phosphorus; this compound of oxygen and phosphorus is commonly spoken of as phosphoric acid.

47. Occurrence of Phosphorus in Nature.—Phosphorus is never found in nature uncombined with other elements. It occurs combined with oxygen and calcium (or lime) and this compound is called *calcium phosphate* or *phosphate of lime.* It also occurs in soils as phosphate of magnesia, phosphate of alumina and iron. Calcium phosphate or phosphate of lime is found in some minerals and in the bones of animals.

48. Importance of Phosphates.—The phosphates, like the nitrates, are found everywhere in the soil and are of great value in their relations to plants. The phosphates found in the bones are taken into the animal body in the food. All plants used as food contain small quantities of phosphorus compounds which they get from the soil. The phosphates taken into the body are partly given off in the excrement and urine.

49. Specific Action of Phosphates Upon Plants.—Experiments have shown that plants will die before reaching maturity, unless they have phosphorus compounds to feed upon. Phosphates appear to perform two distinct functions for plants. *First, they themselves aid in the nutrition of the plant,* and, *Second, they aid the plant,* in some way or other, *to make use of or assimilate the other mineral ingredients.* Phosphorus is mostly found in the seeds of the plant, 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.

DIFFERENT KINDS OF CALCIUM PHOSPHATE.

50. There are three phosphates of calcium (or lime). These are called,

(1). Insoluble Calcium Phosphate.
(2). Soluble Calcium Phosphate.
(3). "Reverted" Calcium Phosphate.

We will consider each of these in turn.

51. Insoluble Calcium Phosphate.—This is also known by several other names, as *Insoluble Phosphate of Lime or of Calcium, Calcium Phosphate, Phosphate of Lime or of Calcium, Normal Calcium Phosphate, Bone Phosphate of Lime, etc.*

This form of calcium phosphate is called *insoluble* because it does not dissolve in water.

It is found in nature in large quantities in several minerals, which will be noticed later. It also constitutes about 85 per cent. of the ash or inorganic matter of bones. It is also contained in the excrement of animals, as in guano, etc.

Insoluble phosphate of lime is found everywhere in the soil. However, in this form, calcium phosphate has the least value for the farmer, because it is not easily dissolved and cannot, therefore, be taken up and used by plants, except very slowly. To make the insoluble phosphate available for plants so that they can take it up, the insoluble phosphate must be converted into some form which is soluble, that is, which dissolves in water. This can be done by treating it with sulphuric acid (oil of vitriol).

52, Soluble Calcium Phosphate is known by various names, as *Acid Calcium Phosphate, Acid Phosphate of Lime, Super-Phosphate of Lime, etc.*—It is not found occurring naturally.

As indicated above, the soluble calcium phosphate is made by treating insoluble calcium phosphate with sulphuric acid. By this treatment, a portion of the calcium is removed from the phosphate and unites with the sulphuric acid, forming calcium sulphate or sulphate of lime, in addition to the soluble phosphate. This mixture of the soluble phosphate and sulphate of calcium is known as "super-phosphate of lime." The phosphate in this form being easily soluble in water can be readily taken up by plants and is, therefore, of great value as a fertilizer. The sulphate of lime is also known to have value as a fertilizer.

The value of super-phosphates depends mainly upon the amount of soluble phosphate contained in them.

53. "Reverted" Calcium Phosphate *or Precipitated Phosphate of Lime.*—When a super-phosphate is allowed to stand for some time, it may happen that some of the soluble phosphate is converted by contact with certain substances into a less soluble form phosphate. This is not the same form as ordinary insoluble calcium

phosphate above described (51), for a "reverted" phosphate, while insoluble in water, can be readily dissolved by weak acids or by water containing carbonic acid or salts of ammonia. Since the soil and plant roots generally contain acids sufficiently strong to dissolve "reverted" phosphates, phosphoric acid in this form is generally regarded as very nearly equal to soluble phosphates in value as a fertilizer. The term "reverted" was introduced to express the fact that the phosphoric acid in this form had once been soluble in water but that it had "reverted" or "gone back" to a form insoluble in water.

54. SUMMARY.—Of the forms of calcium phosphate which are used as food for plants, we have FIRST, the ordinary *insoluble calcium phosphate* (51), which can be changed by sulphuric acid into the SECOND form, *soluble calcium phosphate* (52), and this by standing may be changed into the THIRD form, or that of *"reverted" calcium phosphate* (53), which is insoluble in water but soluble in the acids of the soil and plant.

CHEMICAL DIFFERENCES OF THE THREE PHOSPHATES OF CALCIUM.

55. The three phosphates of calcium are all combinations of calcium (or lime) with phosphoric acid; but they differ chemically in regard to the proportions of calcium, phosphorus, oxygen and hydrogen which they contain.

The following table will give a general idea of the difference in composition of the three phosphates of lime:

	Calcium.	Phosphorus.	Oxygen.	Hydrogen.
Insoluble Calcium Phosphate, Calcium Phosphate, Phosphate of Lime, Insoluble Phosphate of Lime, etc.,	38.7	20	41.3	0.00
Soluble Calcium Phosphate, Acid Calcium Phosphate, Acid Phosphate of Lime, Super-Phosphate of Lime, Soluble Phosphate of Lime, etc.,	17.1	26.5	54.7	1.7
"Reverted" Calcium Phosphate, Precipitated Phosphate of Lime,	294	22.80	47	0.8

56. We notice the following points of difference in composition:

1st. The *insoluble phosphate of calcium* contains the largest amount of calcium, the smallest amount of phosphorus, the smallest amount of oxygen and no hydrogen.

2nd. The *soluble phosphate of calcium* contains the smallest amount of calcium and the largest amount of phosphorus, the largest amount of oxygen and hydrogen.

3rd. The "*reverted*" *calcium phosphate* contains amounts of calcium, phosphorus, oxygen, and hydrogen which are intermediate between the other two forms.

57. With regard to phosphorus, which is the most valuable element in these phosphates of lime, the soluble phosphate of lime contains most of this element; the insoluble phosphate of lime, the least; and the reverted phosphate is second in regard to the amount of phosphorus contained in it.

RELATION OF PHOSPHATES TO FERTILIZERS.

58. The fact that phosphorus compounds are absolutely necessary for the maturity of plants indicates that phosphates are essential to complete fertilizers. Soils become deficient in phosphates more quickly, in general, than in other fertilizing ingredients, and, therefore, when the use of fertilizers is needed at all, phosphates are generally required, whether with or without other fertilizing elements,

ARE PHOSPHATES WASHED OUT OF THE SOIL?

59. The ordinary form of calcium phosphate (51) being insoluble in water, is not, to any appreciable extent, removed from the soil by the drainage water.

The soluble form of calcium phosphate (52) would probably be lost to some extent in drainage water, were it not for the fact that it is quickly changed in the soil to the "reverted" or less soluble form (53), and, in this "reverted" condition, the phosphate is not apt to be carried away in drainage water.

SULPHUR.

60. Occurrence in Nature.—Sulphur uncombined with other elements is found near volcanoes. Combined with other elements, sulphur is found in a great many minerals. Sulphur is

also found in vegetable and animal products, combined with the elements carbon, hydrogen and nitrogen. The properties of the element sulphur are too well known to need any description.

61. SULPHURIC ACID AND SULPHATES.—When *sulphur* is combined with *hydrogen* and *oxygen* in certain proportions it makes *sulphuric acid* (11), commonly called *oil of vitriol.* When the hydrogen of sulphuric acid has its place taken by any metal, a sulphate is formed (12). For example, when the metal potassium takes the place of the hydrogen of the sulphuric acid, a salt is formed known as *potassium sulphate,* commonly called *sulphate of potash;* from sulphuric acid and the metal calcium is formed the salt *calcium sulphate,* commonly known as *sulphate of lime.*

RELATION OF SULPHUR COMPOUNDS TO FERTILIZERS.

62. Sulphur is known to be an essential constituent of plant food. So far as known, plants take it up and use it in the form of sulphates. As a rule, there appear to be in all soils amounts of sulphates sufficient to supply indefinitely all the demands of crops. As the quantity of sulphur used by plants is very small, soils do not readily become exhausted of this element. Therefore, we do not need, in general, to add sulphur compounds to the soil. Calcium sulphate (sulphate of lime) and potassium sulphate (sulphate of potash) are often present in commercial fertilizers, but they are not usually used on account of the sulphur they contain.

CHLORINE.

63. DESCRIPTION AND OCCURRENCE IN NATURE.—Chlorine, when not combined with other elements, is a greenish yellow gas, having a very suffocating odor. The gas is very poisonous and has very active chemical power. Uncombined chlorine is never found in nature. We commonly know chlorine only in its compounds. Chlorine combined with hydrogen forms hydrochloric or muriatic acid (11). Chlorine combined with any metal forms *chlorides,* commonly known also as *muriates.* For example, chlorine combined with the metal sodium forms a compound which is called sodium chloride or chloride of sodium, or muriate of soda (12); and this sodium chloride is the common salt familiar to us in every day experience. Chlorine is always present in soils in such quantities that it does not need to be added to fertilizers.

SILICON.

64. Occurrence in Nature.—Silicon, next to oxygen, is the most abundant element in nature. It does not occur uncombined with other elements. Silicon combined with oxygen forms a compound commonly called *silica.* Quartz and sand are nearly pure silica.

Silicon combined with oxygen and several of the metallic elements, such as sodium, potassium, calcium, etc., forms compounds which are called *silicates.* The feldspars are silicates; clay is a silicate. Ordinary glass consists of a mixture of silicates.

Though silicon is taken up by most plants, it is not definitely settled what its function is, and it is claimed by some that silica is not an essential ingredient of most plants. In some cases it appears to give plants firmness.

Silicon is abundant in all soils in the form of silica and silicates, and does not need special attention in connection with fertilizers.

CALCIUM.

65. Occurrence in Nature and Compounds.—The metal calcium is never found in nature uncombined with other elements. The compounds of calcium are ordinarily known as lime compounds, because calcium, when combined with oxygen to form a compound known as calcium oxide, was called lime, and this calcium oxide or lime was supposed to be present in calcium compounds.

Calcium combined with oxygen and carbon forms a compound which is known as *calcium carbonate or carbonate of lime.* Limestone, marble, chalk, eggshells and coral consist of calcium carbonate or carbonate of lime. Calcium and sulphuric acid form a compound known as *calcium sulphate or sulphate of lime* (12); gypsum and plaster of Paris are familiar forms of calcium sulphate; it is often called simply "*plaster.*"

Calcium combined with oxygen, as already noted, forms calcium oxide, which is commonly known as *lime* or *quick-lime.* This is made by burning some form of calcium carbonate, as limestone, oyster shells, coral rock, etc.; the carbon dioxide (carbonic acid) is driven off by the heat and calcium oxide or quick-lime remains. When quick-lime is exposed to air, it slowly absorbs moisture and carbon dioxide and is changed back into calcium carbonate. When quick-lime is changed into calcium carbonate (carbonate of lime), the lime is said to be *air-slaked.*

RELATIONS OF CALCIUM COMPOUNDS TO FERTILIZERS.

66. All plants contain calcium, but it is not regarded as one of the elements needing special attention in connection with fertilizers, because most soils have an inexhaustible supply of this element, sufficient for the use of plants as food. Calcium is not, therefore, regarded as an essential constituent of a direct fertilizer. However, calcium in the form of sulphate of lime and of quicklime is known to be valuable as an indirect fertilizer.

67. Sulphate of Lime as an Indirect Fertilizer.—Sulphate of lime or calcium sulphate, commonly called *land plaster*, is, as is well known, often used as a fertilizer. Its value is due to its action as an *indirect* fertilizer. There has been much difference of opinion as to the manner in which sulphate of lime acts. Probably it acts in, at least, the three different following ways:

First, it has the power to form compounds with ammonia in which the ammonia is no longer in danger of loss by evaporation. This power of fixing ammonia is probably of little value when plaster is applied to the surface of the soil, but it may be of much value when scattered over a heap of fermenting manure, and moistened with water, when it will retain all the ammonia which would otherwise escape. For the same reason plaster is useful to distribute about stables, so that it may mix with the manure.

Second, it has been shown recently that sulphate of lime, in some unknown manner, aids the process of nitrification, by which ammonia and the nitrogen of organic matter are converted into nitric acid and nitrates.

Third, sulphate of lime acts upon the insoluble forms of potash and some other elements of plant food, converting them into soluble and available forms, which plants can readily take up and use. This is probably the most important effect of plaster as an indirect fertilizer.

In whatever way plaster may act, it is well established that it is of value when applied to certain crops, such as clover, peas, lucern and similar plants. We shall later notice the details connected with its use.

68. Quick-Lime as an Indirect Fertilizer.—Quick-lime or calcium oxide, commonly called lime, is known to be valuable as an indirect fertilizer. It produces changes in both the physical and the chemical character of soils. It changes the mechanical condition of soils by loosening heavy clay soils and also by holding together and giving body to light sandy 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 to the plant. Thus, lime acts upon insoluble mineral substances containing potash, soda, etc., and converts them into soluble forms, which plants can use. Lime aids in the decomposition of animal and vegetable matter, such as vegetable mold, stable manure, etc., and tends to convert them into available plant food. In this change from insoluble to soluble forms, any food not taken up by plants during the season may be washed away before another season and thus lost. In using lime, care should be taken not to use too large quantities and, ordinarily, it is best to use it in connection with liberal applications of actual fertilizing substances.

POTASSIUM.

69. Occurrence and Compounds of Potassium.—The metal potassium is never found uncombined in nature. It is a constituent of many minerals. The decomposition of these minerals gives rise to the presence of potassium compounds everywhere in the soil. It is taken up by plants; and when vegetable material is burned, the potassium remains behind, chiefly as potassium carbonate. When wood-ash is treated with water, or "leached," the potassium carbonate is dissolved out, forming "lye," and this, evaporated to dryness, leaves impure potassium carbonate, which is called *potash.*

In using the term *potash* in connection with fertilizers, potassium oxide is always meant. The compounds of potassium are commonly called *potash compounds,* because it was formerly supposed that potassium oxide or potash was present in all of them.

Potassium combined with chlorine forms potassium chloride or chloride of potash or muriate of potash, etc. Potassium and sulphuric acid form potassium sulphate or sulphate of potash. Potassium and nitric acid form potassium nitrate, also called *nitrate of potash* and *saltpeter* (12).

RELATIONS OF POTASSIUM COMPOUNDS TO FERTILIZERS.

70. Experiments show that when potassium (or potash) compounds are lacking in the soil, the plant suffers greatly, though it does not necessarily die. The development of the woody parts of plants and the fleshy portions of fruits seems to be largely dependent on the influence of potassium compounds. As potash is taken up by vegetation, most soils under constant cultivation sooner or later become deficient in potash, and this loss must be supplied by means of fertilizers. Therefore, potassium (potash) compounds are regarded as essential constituents of direct fertilizers. Potash compounds are not apt to be lost to any extent in drainage waters since most soils have the power of changing soluble forms of potash into forms less soluble, which are gradually redissolved and given up for the use of plants.

SODIUM.

71. Occurrence in Nature.—Sodium occurs in nature mostly in combination with the element chlorine in the form of *sodium chloride* or *common salt*. It is found everywhere in the soil, but usually in small quantities. Sodium and nitric acid form sodium nitrate or nitrate of soda, commonly known as Chili saltpeter.

72. Magnesium, Iron, and Manganese.—These elements, especially magnesium and iron, are present as essential constituents of plants. They are generally sufficiently abundant in all soils, so that they rarely need to be supplied.

THE MOST IMPORTANT ELEMENTS OF PLANT FOOD IN RELATION TO FERTILIZERS.

73. In the absence of iron in the soil, plants turn yellow and cease to grow; and other elements, as chlorine, sulphur, etc., are essential to the complete development of a plant. But these elements are used by plants in very small quantities and, moreover, they occur abundantly everywhere in soils, as already indicated. Therefore, it is unnecessary to supply these elements artificially to soils, and we do not need to consider them in connection with fertilizers. As pointed out in the preceding pages, the elements which experience shows to be generally lacking in soils are three in number, Nitrogen, Potassium, and Phosphorus.

B. CONSTITUENTS OF SOILS.

74. General Composition and Origin of Soils.—Of the fourteen elements necessary to perfect plant growth, ten come exclusively from the soil, as previously indicated. These have already been described, and we do not need to give further attention to them in this place. The soil-derived elements, though forming on an average only about five per cent. of the whole vegetable kingdom, are of the utmost interest and importance to the farmer; for, while the atmosphere is entirely beyond his control, he can, through the medium of the soil, influence the amount of vegetable production.

Soils consist of decomposed rocks, mixed in varying proportions with organic matter called humus, formed by the decay of animal and vegetable substances. The principal part of the soil was once solid rock, and the first step toward the formation of soil was the powdering of the rock. The conversion of rocks into soil has been accomplished by means of various agencies, such as heat and frosts, moving water and ice, chemical action of air and water, and the influence of animal and vegetable life. The value of a soil for agricultural purposes depends largely upon the original material from which it was made, and upon the state of fineness to which it has been reduced.

75. Food Constituents and Mechanical Constituents of Soils.—The constituents of soils can be divided into two general classes, which we will call *food constituents* and *mechanical constituents*.

76. *Food constituents* include the ten soil-derived elements which are essential to the development of plants. They may be divided into two kinds, *available* and *unavailable* food constituents. These terms have already been defined in paragraphs 19 and 20, which see.

77. The *mechanical constituents* of the soil include *clay*, *sand* and *humus*. These act as a mechanical support to plants and as indirect fertilizers. Clay has the power of absorbing and retaining a large amount of water, thus preserving a sufficient amount of moisture in the soil. Clay has the power also of holding ammonia and some mineral salts and again giving them up to plants. Clay, therefore, acts on the available elements of the soil as a sort of regulating material, retaining or yielding them by turns as the

earth passes from a state of drought to one of excessive humidity. *Sand* serves, when mixed with clay, to diminish its compactness, and makes it more porous and permeable to the air.

78. *Humus* is the organic matter in the soil formed by the decay of animal and vegetable matter. It is brown or black in appearance; leaf-mold, swamp-muck and peat are varieties of humus, differing in appearance according to the conditions of their origin and formation. The decay of roots, the plowing under of sod and stubble, and the application of manure cause the formation of humus in the depths of the soil. The composition of humus is somewhat doubtful. It is probably a variable mixture of several substances. Humus is extremely valuable as an indirect fertilizer, for the following reasons: *First*, humus absorbs water much more extensively than any other ingredient of the soil, and thus promotes moisture of the soil. *Second*, humus aids in the decomposition of the mineral matters of the soil, changing unavailable into available plant food. *Third*, humus fixes ammonia in the soil, so as to prevent it from being carried off by the rains; it afterward gives up this ammonia to plants. Humus is, therefore, a very desirable constituent of the soil, and the beneficial effects of stable manure and green manures are doubtless due, in some degree, to the abundance of humus which they furnish to the soil.

ANALYSIS OF SOILS.

79. It is ordinarily supposed that a chemist has only to make an analysis of a soil in order to tell just what the soil needs and what elements should be added to it to make it most productive. What chemical analysis does actually tell is what elements are present in the soil and in what quantities they are present; it does *not* tell whether the elements are available as plant food, and it is just this point which one should know in order to apply to a soil what is needed. Most agricultural chemists to-day do not place much confidence in the chemical analysis of a soil to find out its needs.

89. *How can we find out what elements of fertility a soil needs to make it most productive?* This Station and many other Experiment Stations have been trying to answer the question by letting plants analyze the soil. This is done by laying out several plots of ground; we fertilize one with potash compounds alone, one with nitrogen compounds alone, and one with phosphates

alone. This is varied by introducing on other plots combinations of any two or three of the above constituents. For comparison, some plots are left unfertilized. From such experiments, carefully conducted, conclusions can be drawn as to what element or elements are lacking in the soil for the successful production of any particular crop. Such experiments can readily be carried out by any farmer upon his own land, especially under the direction of some one who is acquainted with such methods of experimenting.

C. RELATIONS OF PLANTS AND SOILS.

81. The general offices which the soil fulfills in its relation to plants are of three kinds. *First,* the soil acts as a mechanical support for plants; the roots of the plant penetrate the soil downwards and sideways, and brace the plant firmly to its upright position. *Second,* the soil furnishes directly all the soil-derived elements used by the plant, and is thus immediately connected with the nutrition of plants. In addition, the soil serves as a medium for conveying to the plant a considerable portion of the air-derived elements. *Third,* the soil contributes to the development of plants by modifying and storing the heat of the sun, by regulating supplies of food, and, in various ways, by securing those conditions which must be present and unite to produce the fully developed plant.

We shall later give statements showing the amounts of different elements removed from the soil by various crops.

RESULTS OF ANALYSES OF COMMERCIAL FERTILIZERS

Manufacturer.	Trade Name or Brand.	Locality where Sample was taken.	Agent taking Sample.	Station No.
Allentown Manufactur'g Co., Allentown, Pa.	Lehigh Phosphate.	Attica.	E. F. Dibble.	618
Bradley Fertilizer Co., Boston, Mass.	Dissolved Bone.	Blood's Depot	E. F. Dibble.	554
Bradley Fertilizer Co., Boston, Mass.	Fine Ground Bone.	Attica.	E. F. Dibble.	620
Bowker Fertilizer Co., Boston and New York.	Hill and Drill.	Canandaigua. East Avon. Delhi.	J. L. Colvin. E. F. Dibble. J.W.M'Cann	167 317 412
Bowker Fertilizer Co., Boston and New York.	Sure Crop.	Canandaigua. Livonia Station. Geneseo.	J. L. Colvin. E. F. Dibble.	168 314 344
Bowker Fertilizer Co., Boston and New York.	Ammoniated Dissolved Bone Phosphate	Livonia Station. East Avon. Delhi.	E. F. Dibble. J.W.M'Cann	313 318 411
Cleveland Dryer Co., Cleveland, O.	Square Bone.	Hamburgh.	C. J. Fenner.	674
Davidge Fertilizer Co., New York City.	Wheat and Corn Compound.	Blood's Depot	E. F. Dibble.	558
E. Frank Coe, New York City.	Ammoniated Bone Super-Phosphate.	Wyoming.	E. F. Dibble.	601
E. Frank Coe, New York City.	Gold Brand Excelsior Guano.	Orient, L. I.	G.E. Aldrich	507

IN NEW YORK STATE FOR THE FALL OF 1890.

Composition of Fertilizers as Guaranteed by Manufacturers, and as Found by Chemical Analysis. Estimated in Parts per Hundred.

	Nitrogen.		Phosphoric Acid.			Potash soluble in Water.	
	Determined as Nitrogen.	Equivalent to Ammonia.	Available.	Insoluble.	Total.	Determined as Potash.	Equivalent to Sulphate.
Guaranteed Found	0.83 1.35	1.00 1.63	7 to 8 7.00	1 to 2 3.25	8 to 10 10.25	2 to 2.50 2.62	3.70 to 4.60 4.83
Guaranteed Found			12 to 15 14.75	1 to 2 1.05	13 to 16 15.70		
Guaranteed Found	2.50 to 3.25 3.49	3 to 4 4.23	—— 7.30	—— 15.68	21 to 23 22.98		
Guaranteed Found	2 to 2.90 2.22	2.50 to 3.50 2.70	8 to 10 9.49	2 2.43	10 to 12 11.52	2 to 3 2.66	3.70 to 5.55 4.91
Guaranteed Found	0.83 to 1.65 1.05	1 to 2 1.30	8 to 10 8.78	2 2.74	10 to 12 11.52	1 to 2 1.45	1.85 to 3.70 2.68
Guaranteed Found	1.65 to 2.50 2.10	2 to 3 2.54	8 to 10 9.85	2 1.85	10 to 12 11.70	1 to 2 2.47	3.70 to 5.55 4.56
Guaranteed Found	2.50 to 3.25 2.74	3 to 4 3.33	8 to 10 9.27	—— 2.45	—— 11.72		
Guaranteed Found	0.83 to 1.65 1.15	1 to 2 1.39	7 to 9 7.65	1 to 3 2.52	8 to 12 10.17	1 to 2 2.14	1.85 to 3.70 3.95
Guaranteed Found	1.75 to 2.00 1.92	2 to 2.50 2.33	8 to 10 10.50	—— 2.47	—— 12.97	1.10 to 1.60 1.84	2 to 3 3.39
Guaranteed Found	2.50 to 3.25 3.20	3 to 4 3.88	8 to 10 8.57	1 to 2 1.25	8 to 11 9.82	6 to 8 5.59	11 to 14.80 10.34

RESULTS OF ANALYSES OF COMMERCIAL FERTILIZERS

Manufacturer.	Trade Name or Brand.	Locality where Sample was taken.	Agent taking Sample.	Station No.
E. Frank Coe, New York City.	Red Brand Excelsior Guano.	Orient, L. I.	G.E. Aldrich	506
E. Frank Coe, New York City.	XXV Ammoniated Bone Super-Phosphate.	PennYan.	J. L. Colvin.	271 272
Listers Agri'l Chemical Works Newark, N. J.	Potato Fertilizer.	Andover.	E. F. Dibble.	584
Listers Agri'l Chemical Works Newark, N. J.	Standard Super-Phosphate of Lime.	E. Bloomfield. Penn Yan. Geneseo.	J. L. Colvin. E. F. Dibble.	254 280 348
Listers Agri'l Chemical Works Newark, N. J.	Success.	Penn Yan. Dundee. East Avon. Caledonia.	J. L. Colvin. E. F. Dibble.	281 285 315 324
Frederick Ludlam, New York City.	Cereal Brand.	Wyoming.	E. F. Dibble.	597
Frederick Ludlam, New York City.	Sickle Brand.	Wyoming.	E. F. Dibble.	598
C. Meyer Jr., Maspeth, L. I.	Acme Potato Fertilizer.	Aquebogue, L. I.	G.E. Aldrich	501
H. S. Miller & Co., Newark, N. J.	Bone and Potash.	Penn Yan. Geneseo.	J. L. Colvin. E. F. Dibble	270 345
Michigan Carbon Works, Detroit, Mich.	Jarves Drill Phosphate.	Castile.	E. F. Dibble.	611

IN NEW YORK STATE FOR THE FALL OF 1890.

Composition of Fertilizers as Guaranteed by Manufacturers and as Found by Chemical Analysis. Estimated in Parts per Hundred.

	Nitrogen.		Phosphoric Acid.			Potash soluble in Water.	
	Determined as Nitrogen.	Equivalent to Ammonia.	Available.	Insoluble.	Total.	Determined as Potash.	Equivalent to Sulphate.
Guaranteed Found	3.25 to 4.10 4.13	4 to 5 5.02	7 to 9 9.27	1 to 2 0.52	10 to 12 9.79	6 to 7 5.65	11 to 13 10.44
Guaranteed Found	0.83 to 1.23 1.44	1 to 1.50 1.73	7 to 9 10.95	1 to2 1.87	8 to 11 12.82	0.80 to 1.20 2.10	1.50 to 2.25 3.88
Guaranteed Found	1.80 to 2.50 2.42	2.20 to 3 2.94	9.25 to 11 11.65	—— 1.25	—— 12.90	4 to 5 4.40	7.40 to 9.25 8.13
Guaranteed Found	2.35 to 2.70 2.77	2.85 to 3.25 3.36	10 to 12 9.52	2 to 3 0.45	12 to 15 9.97	1.50 to 2 2.53	2.80 to 3.70 4.68
Guaranteed Found	1.00 to 1.65 1.73	1.25 to 2.00 2.09	10.50 to 12 9.53	—— 0.55	—— 10.08	1.50 to 2 2.47	2.80 to 3.70 4.56
Guaranteed Found	1.23 to 1.65 1.38	1.5 to 2 1.67	10 to 12 9.57	1 to 3 1.60	10 to 14 11.06	2.15 to 3.25 2.63	4 to 6 4.86
Guaranteed Found			11 to 15 10.94	1 to 3 3.08	12 to 18 14.02	3 to 4 2.65	5.55 to 7.40 4.90
Guaranteed Found	2.90 to 3.25 3.14	3.50 to 4 3.81	6 to 7 7.93	—— 1.21	7 to 8 9.14	8 to 10 8.28	14.80to18.50 15.32
Guaranteed Found			10 to 12 10.32	—— 0.44	—— 10.76	2.50 2.31	4.60 4.26
Guaranteed Found	1.00 to 1.65 1.32	1.25 to 2 1.60	8 to 9 9.93	2 to 3 1.40	10 to 12 11.34	0.27 to 0.54 1.54	0.50 to 1 2.84