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FERTILIZERS AND FERTILIZING MATERIALS.

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ORGANIZATION

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NEW HAMPSHIRE

Agricultural Experiment Station.

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FERTILIZERS.

Probably eighty per cent of all inquiries addressed to the Experiment Station relate to either the use of fertilizer or to stock feeding. Recognizing this fact a *Bulletin* (No. 4) was issued at the beginning of the winter. It will soon be time for the use of fertilizers; next year's crops must be fed, and they in turn will feed the farm stock of 1889–90, therefore, we must, even before the present winter stock feeding ends, commence, indirectly, the next winter's feeding. The first stages, however, does not deal with albuminoids, starch, sugar, oil, etc., but with the elements of which these are made up.

Plants, no less than animals, require food; they create nothing, but simply take the compounds which exist in the air and in the soil and by unknown chemical processes build up starch, sugar, cellulose, vegetable acids, oils, albuminoids, etc. This power belongs exclusively to plants; animals are unable to transform the elements of water and carbonic acid into starch and glucose, or any other organic compound.

If plants must be fed it follows that we must have food upon which to feed them. This we call *plant food.*

To know what plants require we must know what they are made up of. Chemical analysis alone is able to take apart the substance of a plant and tell us what it is composed of. A stalk of corn weighing five pounds, or eighty ounces, was analysed at the Agricultural College Laboratory and found to contain:

		Ounces.
Water,		65.15
Albuminoids,		1.51
Fat,		47
Carbohydrates,	Cane sugar,	4.80
	Glucose,	80
	Starch, etc.,	2.79
	Fiber,	3.65
Ash,		.83
	Total,	80.00

Water is made up of hydrogen and oxygen. Sugar, glucose, starch, fiber and oil are made up of carbon, hydrogen and oxygen, and about eighty-five per cent. of the albuminoids is made up of the same three elements, while the remaining fifteen per cent. is nitrogen. It has been shown by various experiments that all the carbon of a plant comes from a gas called "carbonic acid gas" which exists in the air; the hydrogen and oxygen come chiefly from water.

Nitrogen is believed to come almost wholly from the soil, and the ash also comes wholly from the soil. Thus it appears that the elements from which the 12.51 ounces of starch, sugar, fiber, oil, etc., were constructed came from the air and water; add to this eighty-five per cent. of the albuminoids and we get 13.79 ounces, which with the 65.15 ounces of water gives us seventy-nine ounces out of the eighty ounces total weight of the stalk, which came from the carbonic acid of the air, and from the water of the soil; this water also comes from the air. The remaining ounce is made up of eighty-eight hundredths of an ounce of ash and twelve hundredths of an ounce of nitrogen. With this ounce the study of feeding plants commences, for nature provides the other seventy-nine ounces free.

The figures will be more valuable if we apply them to the product of an acre of land rather than to a single stalk.

The yield was twenty tons, or 40,000 pounds, of corn as it was cut for the silo. This amount contained the following:

		Taken from soil, lbs.	Taken from the air and water, lbs.
Water,			32,580
Albuminoids, (756 lbs.)	Nitrogen,	113	
	Cardon, hydrogen and oxygen,		643
Fat,			237
Carbohydrates,	Cane sugar,		2,400
	Glucose,		400
	Starch,		1,394
	Fiber,		1,825
Ash,		408	
		521	49,379
			521
			40,000

The soil thus contributed 521 pounds of the total yield. It is evident that the exhaustion of the fertility of the soil comes from that portion of the crop which the plant takes from the soil and not the elements taken from the air, and this question at once arises:

In the particular case under consideration was it necessary to supply the whole of the five hundred and ten pounds in order to produce the crop. To answer this it will again be necessary to ask the chemist to tell us what the ash of the crop was made up of. There was

Nitrogen in the albuminoids,	113
Phosphoric acid in the ash,	44
Potash,	120
Soda,	17
Lime,	60
Silica, iron, etc.,	150
Magnesia,	17
Total,	521

Commencing at the bottom of the list we may strike out the seventeen pounds of magnesia, for soils, as a rule, contain all of this substance that is needed; there are exceptional cases where the application of magnesia is beneficial. The one hundred and fifty pounds of silica may be set aside at once; plants get this substance in abundance, for as a matter of fact it is not essential to the growth, but seems an accidental constituent of no special use.

Of the sixty pounds of lime it may be said, that on most soils it is unnecessary to apply it, but even if a soil is deficient in lime, we shall more than make good this deficiency in almost any form of fertilizer we may use, for manures and fertilizers all contain a good percentage of lime.

The seventeen pounds of soda is of no use to the plant, and even if essential it is abundantly supplied by the soil.

But here our work of setting aside must end. Potash is one of the substances that becomes exhaused in soils that have been cropped for a considerable time.

Phosphoric acid is another substance that must be used to restore fertility to worn soils.

Nitrogen is an element about which little is known. It is pretty well understood that plants have the power of getting a considerable portion of their nitrogen from the soil without application from external sources, but this power seems to depend upon the kind of plant to a considerable degree. It is also known that application of manures containing nitrogen are beneficial, but just how much of the nitrogen a crop can supply itself with, and how much may profitably be applied to the soil, is an open question and likely to remain so for some time.

We may now define the term

PLANT FOOD.

It is any substance that can contribute towards the growth of a plant.

Carbonic acid, water, ammonia, phosphoric acid, etc., etc., are examples of plant food.

Plant food may be divided into two classes :

First. Those substances, usually abundant, which we will call *abundant plant food*, including lime, iron, magnesia, silicia, soda, sulphur, water and carbonic acid.

Second. Those that become exhausted by long cropping, which we will call *deficient plant food.* This class includes *potash, phosphoric acid* and *nitrogen.* In special cases soils may be deficient in lime, or iron, or magnesia, and if so then these should be included in the latter class for that particular soil, but in general it is true that only the first three forms are deficient.

Abundant plant food the farmer cares very little about, but *deficient plant food* must always be the chief factor to be regarded in old agricultural regions.

The deficient plant food required by the ensilage crop, above mentioned, narrows down to forty-four pounds of phosphoric acid, one hundred and twenty pounds of potash, and one hundred and thirteen pounds of nitrogen, in all two hundred and seventy-seven pounds, or less than ($\frac{7}{10}$) seven-tenths of one per cent. of the entire crop.

Let us take another case, that of the hay crop 12,000 pounds at time of cutting will make not far from 4,000 pounds, or two tons, when fed out, after shrinking in curing and in the barn.

This 4,000 pounds of cured hay will be made up of the fo lowing :

	Lbs.
Water,	500
Albuminoids,	304
Carbo-hydrates,	2,960
Fat,	56
Ash,	180
	4,000

The ash is made up of the following :

	Lbs.
Phosphoric acid,	**17**
Potash,	**77**
Soda,	2¼
Lime,	20
Silica,	53¼
Magnesia,	10½
	180

This crop of hay would be made up of elements taken from

the air and from water,	11,775
Elements taken from the soil, including nitrogen,	225
	12,000

The *deficient plant food*, or that which must be attended to by the farmer, amounts to one hundred and thirty-nine pounds, made up as follows: nitrogen, forty-five pounds; phosphoric acid, seventeen pounds, potash, seventy-seven pounds.

Is it necessary to provide for all of the nitrogen, phosphoric acid and potash, or will the soil furnish a part of these?

It is a well-known fact, that all soils fit for tillage are capable of producing small crops continuously. Old fields will produce in the vicinity of half a ton per acre of the so-called "June grass," or "white-top," year after year. Such a crop takes from the soil plant food, and when once the crop has reached the lowest limit in its yield and continues year after year practically the same, the plant food contained in this minimum crop represents the *natural capacity* of that particular soil to provide nitrogen, phosphoric acid and potash. Just what this natural capacity amounts to may be illustrated by comparatively definite figures. Lawes and Gilbert, in their famous English experiments, have raised wheat for forty years continuously on their plots, and some have received absolutely no manure in all this time. The following figures show the natural capacity of their soil:

					Bush.
Wheat average for		40 years, no manure,			14
"	"	32	"	"	13⅛
"	"	7	"	"	15⅞
"	"	3	"	"	18
"	"	4	"	"	25⅝

The first two cases are on the same field, the others represent results on different parts of their estate. The average yield of straw for thirty-years was 1,125 pounds.

Taking the experiment plots on our Experiment Station farm and I find that in 1885 we produced on the plots having no manure 47½ bushels sound corn, weighing 40 pounds per bushel; 27⅓ bushels soft corn, weighing 34 pounds per bushel; and 3,246 pounds of well cured fodder. The yield of oats on the same land was 33⅓ bushels, and 1,900 pounds of straw, and the past year the yield of hay was 3,600 pounds. These cases are sufficient to show that soils have considerable producing power when left unmanured. This is accounted for in the following way: All soils fit for agricultural purposes contain a considerable amount of plant food; for example, on the plots above mentioned, where wheat had been produced for forty years and no manure had been applied, there was in the first nine inches of the soil 2,000 pounds of nitrogen per acre. Plots adjoining these and cropped the same, but which had received annual dressings, showed much more. One plot which had received fourteen tons of manure annually had in its top nine inches 4,000 pounds of nitrogen. A soil analysed by the Department of Agriculture showed 4,957 pounds of nitrogen 1,567 pounds of phosphoric acid, 17,429 pounds of potash per acre. If we compare this large quantity with the comparatively small quantity taken up by good crop we shall see that there is enough for a great many crops, but plant food may be present in vast quantities, and yet not be available to the plant. This brings us to a new classification of *plant food*, namely, *available*, that which plant roots can pick up and use for the growth of the plant, and *unavailable*, or that which is insoluble, so that the roots fail to gather in any part of it, and the fact is that a very large proportion of the 2,000 pounds or more of phosphoric acid, or potash, or nitrogen, that is in the soil, is *unavailable*. But so far as the soil produces crops, even if small, plant food is furnished. The average supply of plant food taken up by the 13⅛ bushels of wheat and 1,125 pounds of straw, in Lawes and Gilbert's experiments, would amount to 20 pounds of nitrogen, 17 pounds of potash, and 10 pounds of phosphoric acid, it is evident that this soil is capable of supplying these quantities annually, else the crops would not grow, and this small but necessary allowance comes from the change of *unavailable* plant food into *available* by the action of air and water containing carbonic acid, as well as other more complex influences, which render soluble a limited amount of plant food each year, and this amount is a measure of the *natural capacity* of any given soil. In raising crops, therefore, we need not be at the expense of supplying all of the deficient plant food contained in the crop we raise, but only the excess which the crop contains over and above that which the soil is capable of supplying, year in and year out, indefinitely. It must be remembered, however, that not all of the plant food supplied will be received by the crop. Thus only one-half (50%) of the nitrogen applied in the fertilizer is recovered, the remainder is either lost in the drainage water, or is carried down into the subsoil or held in the soil. It has been demonstrated that very little if any influence is exerted by the *nitrogen* in chemical fertilizer after the second year, and even the second year this influence is very slight. With potash and phosphoric acid the case is different, the effect of a large application being felt for many years. This is explained by the fact that nitrogen in the form suitable to be used by plants is readily washed out of the soil, while potash and phosphoric acid combine with the soil, and though not immediately available are gradually made so, and hence in time will be largely recovered.

On this point the conclusions of Lawes and Gilbert are expressed as follows: "While the soil fixes potash and phosphoric acid independent of vegetation, nitric acid is only fixed by the agency of vegetation."

This being true, it follows that we must apply a sufficient excess of plant food so that the roots may avail themselves of a quantity equal to the excess which the full crop contains above the natural capacity of the land. With nitrogen we should carefully look to see just what amount may be used to advantage, for what is not recovered the first year is quite likely to be lost; with phosphoric acid and potash this is less important since the excess above that utilized by the plant, is retained in the soil and may be had by future crops.

What has thus far been said may be summarized as follows:

First. Plants draw their nourishment from the soil and air.

Second. The term *plant food* is applied to all substances which help to nourish the growing plant.

Third. From one to five per cent. of the food of the plant comes from the soil, the remainder coming from the atmosphere. That which comes from the soil is the part that must be looked after by the farmer.

Fourth. The plant food taken from the soil I have divided into two kinds, one, *abundant*, and so far as the farmer is concerned this requires little or no attention; the other, *deficient*, or scarce in an available form when soils are worn out by cropping. Deficient plant food amounts to about fifty per cent., on an average, of the *total plant food* taken from the soil, (that is the total ash plus nitrogen).

Fifth. All soils fit for agricultural purposes contain a considerable amount of the deficient plant food, even when of low crop producing power. This fact gives rise to a classification of plant food as follows: *available* plant food, or that which is in such a condition that the roots of the plant can take it up in solution; and *unavailable* plant food, or that which the roots cannot make use of.

Sixth. By the action of frost, air, water, carbonic acid, etc., changes are brought about in the soil which annually convert a portion of the unavailable into available plant food, and this portion sustains the natural crop which all soils will produce. This we term the *natural capacity* of the soil to produce crops.

Seventh. If we desire to produce larger crops we must supply a sufficient amount of available plant food in manures or fertilizers to feed the *increase* of vegetation above what the particular soil would produce, but as only a part of the available plant food is recovered by the crop more must be supplied than the analyses of the increased crop would show.

In connection with the subject of fertilization the terms manures, fertilizers, commercial fertilizers, chemical fertilizers, indirect fertilizers, natural fertilizers, artificial fertilizers, superphosphate, complete and incomplete manures, etc., are used, and as there is often a misunderstanding of the meaning of some of these I will give a few definitions which may help us in the following pages.

A *fertilizer* is any substance which furnishes *deficient plant food* in an *available* form.

Fertilizers are either *natural* or *artificial;* the former including manures, or the solid and liquid excrement of animals and green crops plowed in to increase fertility.

The latter, (artificial fertilizers) including *commercial* fertilizers, sometimes called prepared fertilizers, and *chemical* fertilizers, or those mixed from crude fertilizing chemicals.

A fertilizer is *complete*, sometimes called *general*, when it contains nitrogen, phosphoric acid and potash, and *incomplete*, sometimes call *special*, when furnishing only one or two of these deficient forms of plant food. Mixed animal manures are all *complete*, or *general*, fertilizers. Green crops plowed under are complete. The artificial fertilizers, whether commercial or chemical, are complete or incomplete, according as they are mixed from raw materials containing the three forms of plant food above mentioned, or as they lack one or more of these. A fertilizer is said to be *indirect* when it does not contain deficient plant food, but in some way acts on the soil so as to hasten the change of unavailable plant food in the soil into available, that is, they increase the *natural capacity* of the soil. Lime, gypsum, salt, etc., so far as they have any action, belong to this class; others, like ashes, and especially leached ashes, are both direct (furnishing plant food) and indirect.

SOURCES OF PLANT FOOD.

We are now in position to inquire about the sources of plant food, and for our present purposes only the deficient plant food will receive attention, that is, *nitrogen*, *phosphoric acid* and *potash*.

Farm yard manure is the chief source of plant food in mixed agriculture. It consists of two parts, *solid* and *liquid*, the solid portion represents that part of the food which is not digested in the animal system, while the liquid manure contains the waste products of the digested food.

Ordinary farm yard manure, from cows, oxen, and growing cattle, has the following average composition. The composition of horse manure, sheep manure, and hog manure, is also given:

In 1,000 lbs. of manure.	Oxen, cows, etc.	Horse.	Sheep.	Hogs.
Water,	781.0	713.0	646.0	724.0
Dry matter,	219.0	287.0	354.0	276.0
Ash,	40.77	33	36.0	26.0
Potash,	4.80	5.3	6 7	6 0
Lime,	8.11	2.1	3.3	0.8
Magnesia,	1.41	1.4	1.8	0.9
Phosphoric acid,	2.33	2.8	2.3	1.9
Nitrogen,	4.82	5.8	8.3	4.5

In order that we may be able to know the actual amount of plant food applied to an acre, in any given case, I will give the best available figures showing the weight of a cord of manure.

Manure from neat cattle and sheep will weigh not far from 8,000 pounds, or four tons per cord; horse manure, 6,000 pounds, or three tons; while hog manure, as usually found, will probably weigh more than either of those given. As manure is ordinarily drawn in a cart holding forty bushels it will require three loads, without treading to make a cord. The number of cords and tons may thus be estimated with considerable accuracy. In the following table I have figured the actual plant food per ton, per cord, and per load of one-third cord:

DEFICIENT PLANT FOOD IN MANURE.

Manure from		Per ton. lbs.	Per cord. lbs.	Per load. lbs.
Neat cattle,	Nitrogen,	9.64	38.56	12.85
	Phosphoric acid,	4.66	18,64	6.21
	Potash,	9.60	38.40	12.80
	Total plant food,	23.90	95.60	31.86
Horses,	Nitrogen,	11.6	34.8	11.6
	Phosphoric acid,	5.6	16.8	5.6
	Potash,	10.6	31.8	10.6
	Total plant food,	23.8	8.74	27.8

Sheep,	Nitrogen,	16.6	66.4	22.1
	Phosphoric acid,	4.6	18.4	6.1
	Potash,	13.4	53.6	17.9
	Total plant food,	34.6	138.4	46.1
Hogs,	Nitrogen,	9.00	36.0	12.0
	Phosphoric acid,	3.80	15.2	5.0
	Potash,	12.00	48.0	16.0
	Total plant food,	24.8	99.2	33.0

The amount of manure produce l annually has been estimated as follows, for a 1,000 pound ox:

	Nitrogen.	Phosphoric acid.	Potash.
Solid manure, 20,000 lbs. containing,	96.4	46.6	96.0
Liquid " 10,000 "	95.5		160.9
Total per year,	191.9	46.6	256.9

At the prices usually placed upon nitrogen, phosphoric acid and potash, the liquid manure would be worth $23.95, and the solid $23.01, a total of $46.96, provided it could be saved, but owing to the ease with which urine decomposes, there is great difficulty in saving the nitrogen in the liquid manure, and if we remember that $16.71 of the value of the total manure, or thirty-five per cent is in the form of nitrogen in the urine, it at once becomes evident that farmers should take every precaution to save this element.

Those who draw their farm yard manure, liquids and all, and spread them on the land as fast as produced, without doubt handle the urine with the least waste. Next to this the use of a liberal amount of absorbants, cut straw, saw-dust, muck, etc., and the presence of hogs on the manure pile, thus keeping it compact and excluding air, is probably the best method.

BONES.

One of the earliest substances used as a fertilizer, aside from manures, was bone. Waste bone chips and horn parings were first used about 1750, and later, say about 1780–1800, bones became a comparatively common manure in England and Scotland for turnips. An average sample of bone will have the following composition per one hundred pounds: Thirty pounds of animal matter containing two and one-half pouds of nitrogen, and seventy pounds of ash containing fifty-eight pounds of phosphate of lime, made up of twenty-four pounds phosphoric acid and thirty four pounds of lime, the remaining twelve pounds consists of magnesia, carbonate of lime, etc.

It was found by various experiments that the phosphoric acid in the bone was the chief cause of the well-known effect of bone fertilizers. The first great improvement in the use of bone dates with the introduction of a bone mill, by which they were reduced to meal. This was in 1814. The next step was the process suggested by Liebig in 1839, by which bones were dissolved with sulphuric acid; bones thus dissolved, or "cut," with acid were called *superphosphate*, and differ from the raw bone in having the greater part of the phosphate of lime soluble in water, while very little of the lime phosphate in the raw bone is thus dissolved out when treated with water

The term *superphosphate* should only be applied to a fertilizer containing soluble phosphoric acid, and is not correctly used when applied to the *prepared* or commercial fertilizers. In 1843 a new source of phosphoric acid was discovered in Spain. A vein of rock, about seven feet wide, was found there which contained about thirty-four to fifty per cent. of phosphoric acid; in 1844 English farmers tried this new source of phosphoric acid and found it a valuable substitute for bone.

In the United States bone was first used about 1790. The first bone mill was established in 1830, and superphosphate, or dissolved bone, was first tried in 1851.

One of the most important geological discoveries in the United States was that of the so-called South Carolina Rock. This rock is found in masses varying from the size of the fist to fragments weighing a hundred pounds or more, and forms a closely packed layer, covering a considerable area near Charleston, S. C., and in other of the coast states. It is intermingled with shark's teeth and the bones of various animals, which have changed to stone. The "Rock" contains from twenty-five to thirty-two per cent of phosphoric acid. This rock was first put on the market in 1868, six tons being the total output. In 1885 437,856 tons were mined, and in 1887, 480,558 tons.

The phosphoric acid in these rock phosphates is insoluble, but when ground and treated with sulphuric acid they become converted into superphosphates, or soluble phosphates.

Another valuable source of phosphoric acid is in Boneblack. This substance is simply bone charcoal; it is used by sugar refiners, the raw sugars being filtered through it. In this process the impurities of the sugar are held by the boneblack and from the syrup the granulated sugar is crystalized. After a time the boneblack loses its power of removing the impurities, it is then sold to fertilizer manufacturers, for it contains the phosphate of lime originally in the bone.

Crude boneblack contains about thirty-four per cent of insoluble phosphoric acid.

At the present time there is a comparatively new source of phosphoric acid is the so-called Thomas-Gilchrist Slag. This comes from the manufacture of iron or steel from certain ores of iron, which contain phosphoric acid. The slag has about twenty per cent of phosphoric acid in a form not soluble in water.

POTASH.

Until 1868 the chief source of potash was *wood ashes*. It is true that nitrate of potash, or saltpetre, has been used from a very early time, records dating back to 1625, but it was more for the nitrogen which this substance contained, then for the potash; hence we may regard the discovery and use of the "German Potash Salts," as the first rival of ashes. Unleached wood ashes vary very much in their composition, containing from two and five-tenths to eight and one-half per cent of actual potash. In "Canada" ashes* the average is not far from six per cent. of actual potash (K_2O). While leached ashes may contain anywhere from one-half to two and one-half per cent, according to the thoroughness of leaching.

GERMAN POTASH SALTS.

About 1850 an effort was made to open a salt mine at Stassfurt in Saxony. Salt was reached in 1857 at a depth of over one thousand feet. In sinking the shaft beds of potash and magnesia salts were passed through; in 1861 a factory was established to purify these salts and put them in commercial form. The first of these crude chemicals were brought to the United States in 1868. There are several forms of these salts, the muriate, sulphate, also what is called kainit, krugit, etc.

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*Massachusetts Experiment Station Report 1887, average of seventy-one analyses.

NITROGEN.

Nitrogen is a costly element of plant food, its use should be well looked to, when we remember that every pound of nitrogen will cost us not far from twenty cents, while a pound of phosphoric acid (P_2O_5) costs less than eight, and of potash (K_2O) about five cents, it is evident that we cannot afford to be so thoughtless about the nitrogen as we often are about the other two.

As has been already said *nitrate of potash* was one of the earliest fertilizers used, it contains about thirteen per cent. of actual nitrogen. The high value of nitrate of potash as a constituent in the manufacture of gunpowder prevents the use of this source of nitrogen in agriculture, but about 1820 a substitute was found in the so-called Chili Saltpetre, or nitrate of soda. This source of nitrogen was not at first popular, the first ship load going begging for a customer in England, was sent off to this country, at present, however, *Chili Saltpetre* is regarded as a valuable source of nitrogen. It is dug from the ground in South American, where it has accumulated in past ages.

In 1836 "Gas Liquor" was first used in England. This is the water in which illuminating gas is washed, and is found to contain ammonia gas (commonly called hartshorn), ammonia gas is made up nitrogen and hydrogen, fourteen parts of the former to three parts of the latter, the results from the use of this liquor compared favorably with those from saltpetre, but the bulk was too great. Later, by the use of sulphuric acid the ammonia gas was saved in the form of *Sulphate of Ammonia*, which to-day forms one of the best sources of nitrogen.

English farmers long ago learned the value of *dried blood*, and for a time English speculators bought both dried blood and bones in this country and shipped them to be used on English fields, but as the demand for plant food became greater at home, this trade ceased, and to-day this valuable form of nitrogenous fertilizer is extensively used. Meat and fish scrap are also largely used.

These are among the principal sources of the three substances, which I have classed as *deficient plant food*, and in the following table is given the average per cent. of plant food which they contain.

A word of explanation as to what is meant by phosphoric acid, potash and nitrogen.

By *phosphoric acid* is meant a white powder which is made up of the metal phosphorous and the gas oxygen. Chemists express this as P_2O_5, which means two parts by volume of phosphorus and five parts of oxygen.

By *potash* is meant a white substance made up of the metal potassium and the gas oxygen, expressed as K_2O, or two parts by volume of potassium and one of oxygen.

By *nitrogen* is meant the gas which is abundant in its free form in the air. Chemists indicate this by the letter N.

The term *ammonia* is used and often misunderstood. It means one part by volume of nitrogen and three parts of the gas hydrogen, or in chemical work written NH_3. It must be remembered that when a fertilizer is said to contain a certain amount of *ammonia* that it really means that it contains *nitrogen*, but that the amount of nitrogen is only $\frac{14}{17}$ as much as the amount of ammonia.

To illustrate this explanation take sulphate of ammonia in the following table. It contains on an average twenty per cent. of nitrogen, that is, one hundred pounds of the sulphate of ammonia as bought has twenty pounds of the gas nitrogen (N) and it is this twenty pounds that the plant demands, but we might say that the same sulphate of ammonia had twenty-four and one-third per cent. of ammonia (NH_3), hence, if manufacturers print the per cent. of *ammonia* in their goods the farmer must remember that only $\frac{14}{17}$, or eighty-two per cent. of this is plant food, that is, nitrogen.

If a fertilizing material contains fifty per cent. of potash, it means that each one hundred pounds has in it fifty pounds of actual potash (K_2O), or a bone meal that contains twenty-four per cent. of phosphoric acid, has in every hundred weight twenty-four pounds of phosphoric acid (P_2O_5), but fertilizers and fertilizing chemicals have their phosphoric acid in three forms, one *soluble*, that is, it will dissolve in water; another, *reverted*, that is, not soluble in water, but soluble in ammonium citrate solution, this solution having been agreed upon by chemists, and it is assumed that the roots of plants have the power of taking up phosphoric acid in this form, hence, it is common to speak of the available phosphoric acid in a fertilizer, meaning the soluble and the reverted taken together.

Insoluble phosphoric acid is that which is neither soluble in water nor "ammonium citrate."

Table showing sources of deficient plant food, the per cent. of each constituent, the cost per hundred weight delivered in central New Hampshire, and weight per measured half bushel:

Kind of plant food furnished.			Per cwt. of plant food.	Cost per 100 pounds, $.	Weight per ½ bu., lbs.
Phosphoric acid, (P_2O_5).	Insoluble.	Raw bone,	24*	1.75	
		Bone black,	28	1.30	38
		South Carolina Rock,	28	1.25	52
		Bone ash,	35		
	Soluble.	Dissolved S. C. Rock,	16	1.25	30
		" bone black,	16	1.50	30
		" bone,	16	1.75	
Part reverted. (6 per ct.) Part insoluble (15 per ct.)		Thomas-Gilchrist slag,	21	1.25	

*And two and one-half per cent. of nitrogen.

Potash, (K_2O).	Wood ashes,	6	0.50	23
	Muriate of potash,	50	2.40	34
	Sulphate of potash,	22		
	Sulph. potash (high grade)	50	3.50	40
	Kainit,	12	.75	39
	Krugit,	8	.75	39
Nitrogen, (N).	Dried blood,	12	2.00	19
	Fish waste,	7		
	Bone,	2.5*	1.75	
	Nitrate of soda,	15	3.00	44
	Nitrate of potash,	13	5.00	
	Sulphate of ammonia,	20	4.00	31

*And twenty-four per cent. phosphoric acid.

G. H. WHITCHER, *Director.*

These Bulletins are sent FEEE to all persons in the State who request them. A postal card with your name and address will insure the publications as issued.

Address all communications to N. H. EXPERIMENT STATION, HANOVER, N. H.