2nd Series

BULLETIN NO. 2.

SECOND SERIES.

Department of Agriculture,

STATE OF ALABAMA.

FERTILIZATION

PREFACE.

As the season is at hand when the attention of farmers will be invited to the multiplicity of commercial fertilizers upon the market, I thought it advisable to address a few remarks upon the principles, methods, and materials of systematic fertilization. For the greater part of the matter of this Bulletin, I am indebted to other parties, chiefly, however, to an article of Professor Jordan, of the Pennsylvania Board of Agriculture.

E. C. BETTS,
Commissioner of Agriculture.

FERTILIZATION.

WHAT PLANTS CONTAIN.

Plants have been found to contain the following elementary substances, viz: Carbon, oxygen, hydrogen, nitrogen, silicon, sulphur, phosphorus, chlorine, iron, aluminum, calcium, magnesium, manganese, potassium, and sodium. Instead of using the names of the elements proper, we speak of some of the above substances as silica, sulphuric acid, phosphoric acid, lime, magnesia, potash, and soda, these being compounds of the above-named elements with oxygen.

Familiar substances consisting of these elements, or in which they are found, are as follows: Carbon is seen in the form of coal. Oxygen and nitrogen are the two principal constituents of air. Hydrogen is united with oxygen to form water. Silica is common quartz rock. Phosphoric acid is a principle constituent of bones. Chlorine and sodium unite to produce common salt. Sulphur and iron are very familiar substances. Caustic lime is a compound of calcium and oxygen, as the magnesia used medically is of magnesium and oxygen. Potash is contained in the commercial "potash," which is really carbonate of potash. Four of these elements—carbon, oxygen, hydrogen, and nitrogen—disappear in the air when a plant is burned, and all the others remain behind in the ash. Such is the case with wood or any vegetable substance.

NATURAL SOURCES OF PLANT FOOD.

No matter how luxuriantly a plant may grow, it is able to obtain all its carbon from the carbonic acid of the air, which enters the plant through the leaves. It is an erroneous idea to suppose that the carbonic acid of the soil is necessary for supplying the plant with carbon. The source of the oxygen and hydrogen is undoubtedly water, which enters the plant through the roots. Nitrogen can only be furnished to the plant in its compounds, principally ammonia and nitric acid. The free nitrogen of the air is useless as direct plant food. Nitrogen compounds enter the plant through its roots. Even the nitric acid and ammonia of the air must first be carried to the soil by rain before they can become useful. The soil contains at all times small quantities of ammonia and nitric acid. These compounds are being continually used by growing vegetation, and as continually supplied from the air and from decomposing organic matter, besides what comes from artifical sources. The mineral ingredients of a plant, such as sulphuric acid, phosphoric acid, lime, magnesia, potash, &c., come entirely from the soil, being taken up by the roots. There is no soil, unless it be of the most extraordinary character, that does not contain all the elements of plant growth in quantities that vary from a mere trace to a large percentage. So there is no soil that will not support vegetation of some kind, though it be ever so scanty.

THE INDISPENSABLE ELEMENTS OF PLANT GROWTH.

It is very natural to suppose that whatever is found in a plant is essential to its growth and development. Such, however, is not the case. Plants have been grown to fullest perfection in water solutions that contained no silica, chlorine, sodium, or manganese, or only minute traces. The ten substances, the absence of any one of which would be fatal to plant growth, are carbon, oxygen, hydrogen, nitrogen, sulphuric acid, phosphoric acid, lime, magnesia, iron, and potash. Take every trace of phosphoric acid or potash out of a soil, and it would be as barren as pure quartz sand. The absence of one of the ten ingredients would be as fatal as the absence of all.

RELATION OF DEMAND AND SUPPLY.

The one important consideration in agricultural practice, is the relation of demand and supply of plant food. If there are certain materials the farmer must have in order to produce crops, it is of the utmost interest to him that he should know the extent of the supply that nature offers of the various constituents needed, and how this supply is able to meet the demands. Let us see what are the facts.

We can get some light on the matter under discussion by looking carefully at the composition of an average soil, and calculating what it would contain of the various necessary ingredients of plant food. The following figures show what was contained in a fine English wheat soil:

	Pounds in 1000 of soil.	*Pounds in one acre to the depth of one foot.**
Silica	715.5	2,502,500
Iron oxide	51.7	182,000
Lime	12.3	43,050
Magnesia	10.8	37,750
Potash	3.5	12,250
Sulphuric acid	.44	1,540
Phosphoric acid	4.3	15,050
Nitrogen, (average of analyses of several soils,)	2.2	7,700

Below is given a similar statement for a South Carolina soil, probably in poor condition:

	Pounds in 1000 of soil.	*Pounds in one acre to the depth of one foot.*
Silica	885.9	3,100,650
Iron oxide	8.3	85,050
Lime	3.2	11,200
Magnesia	1.37	4,795
Potash	.06	210
Sulphuric acid	.8	2,800
Phosphoric acid	.59	2,065

We need but to glance at the above figures to see that

*Soil to depth of one foot estimated to weigh 3,500,000 pounds.

whether we take the excellent wheat soil or the poor one from the south, the essential and most important ingredients are present in the smallest relative quantities. Now, while the analysis of ordinary soils tells very little as to their state of fertility, it shows us what compounds would be soonest entirely used, provided all the ingredients of the soil were in equal demand. And it is a fact, that none of the ingredients entering into a plant, excepting those that come from carbonic acid and water, are needed to any greater extent than is the case with nitrogen, phosphoric acid, and potash, substances that even the best soils contain in very small percentages. But we are not shut up to this method of ascertaining the explanation of soil exhaustion. We find that if we apply to a field producing scanty crops, a fertilizer containing nitrogen, phosphoric acid, and potash, in forms available for the use of plants, an increase of fertility follows. The only explanation of this is, that what has been supplied is that which was lacking of the ingredients absolutely indispensable. It is often the case, that lack of fertility is not due to a deficiency of plant food so much as to unfavorable mechanical conditions, presence of poisonous ingredients, &c. The carbon of the plant, as before stated, is taken from the air, and the supply is inexhaustible, for the reason that the amount used by vegetation is balanced by the quantity that passes into the atmosphere from combustion and from decay of organic matter.

SOIL EXHAUSTION.

The explanation of soil exhaustion and its remedy can be epitomized in the following statements:

1. To grow fifty bushels of corn, a certain quantity of a certain number of ingredients is absolutely necessary.

2. The soil and air can always furnish a sufficient quantity of a part of these ingredients, while the supply of others in an available form may become exhausted.

3. The essential materials for vegetable growth that the soil and air can always furnish in abundance, are oxygen, hydrogen, carbon and iron; sulphuric acid, lime and magnesia being very seldom wanting. So long as only minute quantities of silica and chlorine are needed, we have no occasion to fear but that any soil will meet all the demands that can be made for those substances. Inexhaustible stores of carbon exist in the air, and in decaying vegetable and animal matter; oxygen and hydrogen are as free as water, while it would be utter nonsense purposely to put iron in a fertilizer.

4. The substances of which plants most often find a scanty supply are nitrogen, phosphoric acid, and potash. A "run out" soil may lack one, two, or all of these in an available condition, but a soil is seldom found that fails in any other materials.

5. The main reason why substances called manure cause an increase of crop, is that they contain all or part of these valuable ingredients, nitrogen, phosphoric acid, and potash. This is true of both commercial and farm manures.

6. The chief value of any manure depends upon what it contains of these last-mentioned substances. It is not a question of bulk, color, odor, or any other condition save this, that chiefly determines the value of manures. Remove these three ingredients wholly from any manure, and it would be of very little value.

To say that a soil is exhausted, does not mean that any single element of plant food has been entirely withdrawn from it. Such is practically never the case. The failure of land to produce satisfactorily, comes at a point far short of the complete removal of any one of the necessary constituents. A field that would not produce over five bushels of wheat to the acre, may contain a hundred times more of every element of growth than would be needed for a luxuriant crop. Exhaustion means no available material rather than no material at all, and this fact has an important bearing upon the question of tillage.

Fertility, in the broadest sense of the term, includes more factors than the mere matter of soil exhaustion. Mechanical conditions, such as looseness or compactness, fineness or coarseness, a very loose sub-soil or an impervious sub-soil, often set a limit to production independently of the supply of plant food.

The points that we need to consider for a full understanding of our subject, are the following:

1. The extent and the manner of exhaustion which result from the selling of the various products of the farm.

2. The means of keeping up the productiveness of the soil. (*a*) By using what the soil already contains. Or, (*b*) By the application of manures.

THE VALUABLE INGREDIENTS CONTAINED IN THE VARIOUS PRODUCTS OF THE FARM.

The only method of determining how much is abstracted from the soil by any farm product is by chemical analysis. It has been found by this means about what are the percentages of valuable constituents that are contained in all kinds of vegetable and animal material. In the following table are given figures that allow the computation of the extent of exhaustion that occurs in the growth of the ordinary farm crops and in the sale of meat, milk, cheese, and wool. The quantities given are what are contained in one thousand pounds of the fresh or air-dried product:

KINDS OF PRODUCT.*	Nitrogen.	Potash.	Lime.	Magnesia.	Phosphoric acid.	Sulphuric acid.
Timothy	13.5	20.3	4.7	1.9	6.9	1.7
Clover	19.7	18.6	20.1	6.3	5.6	1.9
Green fodder corn	1.9	3.7	1.4	1.1	1.0	0.3
Potatoes	3.4	5.8	0.3	0.5	1.6	0.6
Fodder beets	1.8	4.8	0.3	0.4	0.8	0.3
Sugar beets	1.6	3.8	0.4	0.6	0.9	0.3
Turnips	1.8	2.9	0.7	0 2	0.8	0.7
Wheat (kernel)	20.8	5.2	0.5	2.0	7.9	0.1
Rye, (kernel)	17.6	5.8	0.5	2.0	8.5	0.2
Barley, (kernel)	16.0	4.7	0.6	2.0	7.8	0.4
Oats, (kernel)	19.2	4.8	1.0	1.9	6.8	0.5
Corn, (kernel)	16	3.7	0.3	1.9	5.7	0.1
Field beans, (kernel)	40.8	12.9	1.5	2.2	12.1	1.1
Wheat straw	4.8	6.3	2.7	1.1	2.2	1.1
Rye straw	4.0	8.6	3.1	1.2	2.5	1.6
Barley straw	6.4	10.7	8.3	1.2	1.9	1.8
Oats straw	5.6	16.3	4.3	2.3	2.8	2.0
Maize straw, (stover)	4.8	16.4	4.9	2 6	3.8	2.4
Tobacco leaves	34.8	40.9	50.7	I0.4	6.6	8.5
Cow's milk	5.4	1.7	1.7	0.2	2 0	0.1
Cheese	51.2	6.6	17.7	1.2	19.2	0 1
Live ox	26.6	1.7	20.8	0.6	18.6	
Live sheep	22.4	1.5	13.2	0.4	12.3	
Live swine	20.0	1.8	9.2	0.4	8.8	
Wool, unwashed	54.0	56.2	1.8	0.4	0.7	
Wool, washed	94.4	1.9	2.4	0.6	1.8	

By the help of the above table we are able to estimate approximately the loss incurred in sending away from the farm the salable produce of one acre.

Only the quantities of the three most valuable substances are given:

*These figures are taken from *Mentzel und V. Lengerke's Landwort Kalender for 1882.*

Estimated Crops.	Nitrogen.	Phosphoric acid.	Potash.
	Lbs.	*Lbs.*	*Lbs.*
Timothy hay, (2 tons)	54	27.6	81
Clover hay, (2 tons)	78.8	22.4	74.4
Green fodder corn, (15 tons)	57	30	111
Potatoes, (150 bushels without tops)	30.6	14.4	52.2
Fodder beets, (20 tons)	72	32	196
Sugar beets, (20 tons)	64	36	152
Wheat, (25 bushels without straw)	31.2	12	7.8
Wheat, (25 bushels with 1¼ tons straw)	43.2	17.5	23.5
Oats, (40 bushels without straw)	23	8.2	5.8
Oats, (40 bushels with 1¼ tons straw)	37	15.4	46.5
Corn, (50 bushels without stover)	44.8	16	10.4
Corn, (50 bushels with 1¼ tons stover)	56.8	25.5	51.4
Milk of ten cows, (40,000 pounds)	216	80	68
Cheese from ten cows	200	37	13
Pure butter fat from ten cows	00	00	00
One steer weighing 1,000 pounds	26.6	18.6	1.7

The above figures are not intended to show the amounts of nitrogen, phosphoric acid, and potash needed for the growth of the whole plant, but simply what would be removed in the parts that could be sold. It is easy to see that different crops exhaust the soil very differently. For instance, the amount of potash removed by root crops is very large; and land in Germany that had grown sugar beets for years, became "beet sick," a disease that was cured by the use of potash salts. Grain, whether wheat, oats, or corn, removes in the kernel most of nitrogen and least of potash, while in the straw, potash preponderates.

It is commonly remarked by farmers, that timothy is more exhaustive than clover, and oats more than wheat, but neither statement is true. The effect that the growth of any crop has upon the one that succeeds it, should not be taken as a measure of the amount of soil exhaustion.

It must also be borne in mind, that the amount of any substance that a plant takes up, is not a measure of the difficulty with which it obtains the material. For instance, an acre of land would need to contain more available nitrogen in order for twenty-five bushels of wheat to be grown, using about thirty-one pounds of nitrogen, than would be necessary for the growth of two tons of clover hay, using nearly eighty pounds of nitrogen. In other words, clover can gather nitrogen more easily than wheat.

A study of the fist table reveals one fact of great moment to the farmer. It is plainly shown that it makes a great difference as to the form in which a farmer sells his surplus productions, if he would husband the resources of his land. In selling an ox weighing one ton, only as much nitrogen is sent from the farm as would be lost by selling about one and one half tons of English hay. Of phosphoric acid, such an animal represents an amount found in less than five tons of hay, while an eighth of a ton of hay would furnish the ox with all the potash he has in his body. If the farmer were to sell the hay and grain necessary to be used in the production of two thousand pounds of live animal weight, he would send from his farm vastly more of those substances that have a manurial value, than if the animals had been grown and the manure returned to the land from which the hay or grain was taken. It will be seen later, that when food passes through an animal, only a small portion of its nitrogen, phosphoric acid, and potash is retained, while a larger part of these substances passes into the manure. Unless a farmer buys manure, the mathod of farming surest to retain or increase the fertility of his fields, consists in the production of meat or butter.

Selling milk or cheese would eeonomize the resources of the farm to a less extent, while the most wasteful course of all to pursue, is the selling of crops as such. Any man's method of farming must depend very largely upon his locality and other circumstances. Any method that results in the impoverishing of the soil is unwise and often ruinous, even as a temporary expedient.

We come now to the question of the means of keeping up the supply of available plant food.

PLANT FOOD FROM NATURAL SOURCES.

In the case of nitrogen, nature makes a partial return for what vegetation takes, by means of rain water which absorbs ammonia and nitric acid in its descent through the air. But this amounts to less than ten pounds of nitrogon per acre for each year, a quantity much less than the average amount carried off by crops, as can be seen by the last table given. Phosphoric acid and potash do not have any source outside the soil save what is supplied by the farmer. Now we have seen that a soil may contain several thousand pounds of nitrogen, phosphoric acid, and potash, and still be unable to produce a satisfactory crop of wheat containing less than one hundred pounds of each of these ingredients. In a majority of cases, if such land be fallowed, its productiveness for the succeeding year will be increased.

FALLOWING.

Fallowing, then, is one of the means adopted for keeping up the crop-growing capacity of land. The unfortunate thing about it is that it adds nothing to the soil, but is an expedient adopted for the more complete use of what is already there. Fallowing promotes decomposition. Land turned up in furrows and submitted, in a naked condition, to the action of the sun's heat, of the air, and of rain, meets with certain changes that make available material previously not at the command of growing crops. Moreover it allows an accumulation of plant food, for there is nothing to use this as fast as it becomes available. In the true sense, however, fallowing is exhaustive. In one way it is wasteful, for, to say nothing of the land lying idle, there is a greater loss of nitrogen by the leaching away of nitric acid, than is the case when vegetation stands ready to use this compound as soon as formed. There is some land that is so poor, either naturally or by cropping, that, unless manured, it needs to remain idle about two years out of three in order to accumulate sufficient available plant food to insure the growth of a paying crop. Fallowing, be it for one season or for several, does not belong to a system of high farming, and can hardly be recommended on any but the cheapest lands.

Another method of making drafts on the reserve stock of material in the soil is by the use of

LIME.

Lime is in no sense a true fertilizer. We generally use it, not because there is a lack of it in the soil for the purposes of plant growth, but as a decomposing agent. Some speak of lime as an "amendment," but it is not often even that, though it may sometimes serve to increase the absorbtive properties of the soil. It is not strange that when an increase of production has been seen to follow an application of lime, it has been supposed that the soil was supplied with some needed element of fertility, when, in reality, nothing was done but the bringing into use material not previously in an available condition. The exclusive use of lime in the production of crops will finally be destructive to fertility, even on our best farming lands, and an ignorance of this fact has been productive of great harm to agriculture. Liming is a correct practice only on farms receiving constant applications of yard manure. The decomposing effect is here needed to break down organic matter which has a tendency to remain in an inert condition.

CLOVER AND PLASTER.

The use of clover as preparatory to the wheat crop, is still another road that leads finally to exhaustion of the soil. This statement may be a matter of surprise to some. It is not intended to convey the impression that clover should not enter into the rotation, for it is a valuable auxilliary to profitable farming. What is meant is that the farmer who places his main dependence upon clover to furnish his wheat with material for growth, will eventually come to grief. When the remark is heard, "I can't grow wheat now, for I can no longer get a catch of clover," it can be set down that the speaker is tilling fields exhausted by the very use of that which he laments as no longer at his command. Clover adds nothing to the soil save the carbon taken from the air. The nitrogen, phosphoric acid, and potash that enter into its composition, it obtains from the soil as do other plants. Of these three ingredients, clover roots contain a good percentage, and when the sod is turned over, and these roots decay, the wheat plant finds, ready for use, food that otherwise it would need to gather for itself, which, in many cases, would be impossible. When the wheat is gone the field is the poorer by the amount of valuable ingredients that the crop contains, for the soil was their original source. The use of plaster to help the clover, and so indirectly to help the wheat, is but an aggravation of the offense. Plaster contains sulphuric acid and lime, but no nitrogen, phosphoric acid, or potash. Its effect is somewhat analagous to that of lime, because it helps make a larger use of that which the soil already contains. Its usefulness in gathering and retaining ammonia has probably been exaggerated. Lime, plaster, and clover are a part of good farming in conneetion with real fertilizers, but as a sole dependence their use is simply putting off the evil day.

The second and most important division of our subject is that of obtaining

PLANT FOOD BY THE USE OF MANURES.

Manures are of two general classes, commercial and those produced on the farm. Both are of importance, and both demand careful consideration.

COMMERCIAL MANURES.

We have in our markets a class of substances known as commercial fertilizers. Whenever they are of value, they contain one or more of the ingredients of plant food that have been pointed out, as especially liable to be lacking in the soil, in a form available to plants. In all first-class commercial manures these ingredients exist in quite large per centages; they are concentrated as compared with farm manures. While there would be three hundred and twenty pounds of phosphoric acid in a ton of first-class dissolved bone, (superphosphate,) in a ton of farm manure from good hay, there would be only four or five pounds. Dried fish scraps would contain per ton, one hundred and fifty to one hundred and sixty pounds of nitrogen, if of good quality, but not over a dozen pounds of that ingredient could be found in a ton of stable manure from the best of hay. Condense animal excrement by ridding it sufficiently of its large quantities of carbonaceous material and water, and it would then approach in character the fertilizers of our markets. Commercial manures are, or ought to be, concentrated plant food.

CLASSES OF FERTILIZERS.

The fertilizers called "commercial," are made up of various classes, according to their principal ingredient. They are nitrogenous, phosphatic, or potash manures, according as they contain principally nitrogen, phosphoric acid, or potash. Some fertilizers can not be distinguished by either of the above names, because they are made up of a mixture of two, or all of the three valuable ingredients.

Below are given the names of most of the principal manures sold in our markets, arranged in classes as indicated above:

Nitrogenous Manures.	Phosphate Manures.	Potash Manures.
Nitrate of soda, (Chili saltpeter.	Superphosphates.	Sulphate of Potash.*
Sulphate of Ammonia.	Phosphatic guanos.	Mur iate of potash*
Fish Scrap, (fish guano).	Bone meal.	Unbleach'd wood ashes
Dried blood.	Bone ash.	
Meat scrap.	Bone black.	
Horn dust.	Phosphatic rock.	**Potash salts.*

SOURCES AND CHARACTER OF THE VARIOUS FERTILIZERS.

Perhaps a brief description of the sources and character of the commercial fertilizers in most common use may not be out of place.

Nitrate of soda, or Chili saltpeter, is obtained from the immense beds of that substance found in South America. The itrogen exists in it as nitric acid, (the *aqua fortis* of commerce,) and is united to soda. In the saltpeter used medicinally the nitric acid is united to potash instead. Nitrate of soda should contain 15 to 16 per cent. of nitrogen, unless largely diluted with some other substance. It is very easy to do this with common salt, and the fraud escapes detection by any ordinary method of examination. As common salt is much the cheaper material there is a strong temptation to such dishonesty. The nitrogen purchased in nitrates costs more per pound than when bought in any other form. In scch combinations it is in a condition to be immediately used by plants. It should be remembered, however, that the soil has but little power of retaining nitric acid, and, therefore, when nitrogen is used in this form it should not be applied to the land very long before it is to be used by the growing crop, else it may be leached out and carried off in the drainage water.

Sulphate of ammonia is obtained from the waste products of gas manufacture. The nitrogen, in the form of ammonia, is combined with sulphuric acid, (oil of vitriol,) and costs less than when bought in Chili saltpeter, being valued by the Connecticut Experiment Station at three and one half cents less per pound. A good sample of sulphate of ammonia should contain 20 per cent. of nitrogen; but, like nitrate of soda, it can be easily adulterated with several cheaper substances. Ammonia is not leached from the soil like nitric acid, only to the extent that it is oxidized and converted into the latter; therefore, its application some time previous to the time of planting or sowing is not so dangerous as it would be to use nitrates in such a manner. It is probably advisable, however, to apply both forms of nitrogen in the spring.

Dried blood, dried fish, meat scraps, and all animal substances contain nitrogen in the organic forms in which it was built up in the animal body. When in such combinations, it can not serve as plant food until a certain amount of oxidation or decomposition has taken place. The various organic substances in the market differ very much in the ease and rapidity with which they decompose and render available their nitrogen in the form of ammonia or nitric acid. This transformation takes place rapidly with dried blood, fish, and meat; but slowly with hair, horn, and leather waste. This important difference

has an effect upon the price and upon the methods of using such nitrogenous fertilizers. Such materials as horn dust, leather waste, &c., would be of value to a crop if applied to the soil long enough before the crop is grown to allow considerable previous decomposition; so that while it may not be an incorrect practice to manure a piece of land with dried blood just before it is sown to wheat, any substance resembling horn should be applied some months previous. A very good method of effecting the decomposition of animal substances that do not readily pass through such a process is to compost them. By this means their manurial value is more quickly and profitably utilized. More or less insoluble phosphoric acid is contained in the above mentioned organic manures, which slowly becomes available. In acidulated fish the phosphoric acid is to an extent souble as in a superphosphate. Nitrogen in the organic form varies in price according to the substance containing it, costing in fish scraps and horn only three fourths what it does in dried blood and meat. In any case a finely powdered fertilizer of this class would in justice bear a higher price than one very coarse. Certainly the agricultural value is increased by fineness of division.

Superphosphates contain phosphoric acid as their principal ingredient. They are manufactured by treating some form of bone or phosphatic rock with oil of vitriol. Part of the phosphoric acid is thus rendered soluble in water, the amount of this depending upon the quantity of oil of vitriol used. A portion of the bone or rock is not acted upon; but this amount need be very small. The larger part should have its phosphoric acid rendered soluble. Besides the "soluble" and "insoluble" forms of this ingredient, we have in nearly all superphosphates a form called "reverted." This name applies to the phosphoric acid that was at first rendered soluble in water, but by chemical change has become insoluble in that liquid. Its chemical and molecular conditions give it a value greater than though it never had been soluble. Its value, as compared with that which remains souble, is not determined; some experiments seeming to show that it is of equal value. In the market, however, it takes a lower valuation. Superphosphates made from ground phosphatic rock, (usually phosphorite,) are more likely to contain reverted phosphoric acid than those made from bone, owing to the influence of the iron and alumina compounds in the rock. Moisture also has a tendency to cause reversion.

The commercial values of the different forms of phosphoric acid, soluble, reverted, and insoluble, diminish in the order mentioned. The insoluble is valued in price according to the form and condition of the substance containing it. When in bone, its value varies with the fineness of the bone. It is worth the least in ground rock. It is well known that superphosphate has a much more immediate effect on crops than bone or phosphorite that has not been treated with oil of vitriol. This results from the solubility of the phosphoric acid in the superphosphate, at least, that is the explanation offered. But how is it that solubility is able to affect the value of this ingredient? Is it simply because that when soluble, it remains so in the soil and can thus be readily taken up by plants? Not at all. Phosphoric acid when applied to the land in a superphosphate, remains soluble but a very short time. The lime, iron, and alumina compounds in the soil soon precipitate it over the particles of earth, but in a very finely divided condition, so that the soil—water, and roots are enabled to make a solution sufficient for the use of growing plants. Solubility seems desirable, chiefly, as a means of obtaining an extensive, even, and intimate mixture of the phosphate with the soil.

From the facts just stated, it would seem that the finer bone is ground, the more nearly will its effect compare with that of superphosphate, so far as the phosphoric acid is concerned. Differences in the value of bone, according to its degree of fineness, are recognized by the Connecticut experiment station.

Nevertheless, bone meal is not a manure that generally causes a large increase of growth the first year of its application. At the same time its phosphoric acid is the most valuable of any that can be obtained in the insoluble condition. It is not advisable to apply bone meal to land, when the full benefits of it

are desired at once. It is most rationally used where a gradual, lasting effect would be profitable. An admirable way to utilize bone meal or even ground phosphatic rock, when a farmer has land that responds to phosphoric acid, is to mix it with a fermenting manure or compost heap. The carbonic acid generated in a pile of moist decaying organic matter, is able to bring into an available condition a portion of the phosphates, which action in the case of the bone meal is aided by the fermentation communicated to it.

No farmer should ever buy bone black to apply to the land as such, for it is very slow in giving up its phosphoric acid, owing to the presence of carbon, which protects the particles of phosphate from decomposing influences. Phosphatic rock is still slower in allowing its phosphoric acid to become available. The application of any phosphate that has not been treated with sulphuric acid, can not be depended upon to cause a large increase of crop the first year. It is manufactured on a small scale by some farmers. Bones can be purchased before they are ground, for a cent a pound; bone meal costs nearly two cents per pound. If one lives near a bone-mill, and can get the bones, it is a much cheaper way to purchase them and have them ground, than to pay thirty-five dollars per ton for no better bone meal. When a small quantity of superphosphate only is desired, it is doubtful if it is wise to take the trouble of manufacturing it; if one has a demand for several tons, it is another matter. It is wise, however, to save all the bones that collect about the house; purchase all that can be conveniently obtained from the neighbors, and then after they are crushed, put them in the compost heap or in moistened ashes. Do not burn them, as they contain considerable nitrogeneous material that is valuable. Bones decompose more quickly if the fat is extracted by steaming.

The idea of obtaining phosphoric acid cheaply, by purchasing its insoluble forms and submitting them to the action of a compost heap, is undoubtedly a practical one for a farmer, who finds that his soil needs that ingredient. A pound of insoluble phosphoric acid can be purchased for three and a half to five cents, costing twelve and a half cents when bought of the manfacturers in a soluble condition. If the consumer can get the same effect without paying the extra cost, it is exceedingly wise to do so.

Potash manures come largely from Germany in the shape of potash salts. We have also potash that is extracted from ashes, but it is not used in this form as a fertilizer. The German potash salts are mined, and exist at first associated with other minerals. They are purified and sent to this country in quite large quantities. The substances found associated with them are common salt, and the sulphate and chloride of magnesia. These compounds are not always sufficiently removed from the imported potash manures, and while the common salt and sulphate of magnesia do no harm, chloride of magnesia in any considerable quantity is actually poisonous to plants.

For this reason it is well to apply potash salts, especially the chloride, to the land, some little time before the seed is put into the soil, so that the poisonous compounds, if present, can become sufficiently diffused to prevent harmful results. The sulphate of potash is the safer manure to use, but it is more costly than the chloride, (muriate.)

Unleached ashes contain quite a percentage of potash, which varies much according to the wood from which the ashes come, and the manner of burning. The potash in wood ashes is in a valuable form, (the carbonate,) and usually can be bought as cheaply in this as in any other form, if we take into account the phosphoric acid and lime which the ashes contain besides.

Good hard wood ashes from wood burned in fire-places or cooking stoves, are well worth twenty-five cents a bushel to any farmer, if he finds that his farm needs potash. The question is often asked, what is the difference between leached and unleached ashes, and which is the cheaper at ordinary prices? The chief difference is that the former contain much more potash than the latter. The process of leaching takes out nearly all the potash.

Now as to which kind a farmer had better buy, depends upon what he wants of the ashes. If his land needs potash manures,

then he had better buy the unleached; but if he wishes to use the ashes simply as a means of liming his land, then the leached will serve his purpose just as well and be much cheaper. The manner in which a farmer is to learn whether he needs potash, lime, or any other ingredient applied to his fields, we will consider later.

THE COMMERCIAL VALUE OF FERTILIZERS.

No one can tell the value of a superphosphate by its color or odor. Not even by applying it to the soil can its *commercial* value be told, only its value to the man who uses it. It may do no good in one case and much good in another, but neither test can determine what it is worth in the markets. That is determined by the demand and supply. The commercial value of any particular fertilizer depends upon its composition, and that the chemist must discover.

Just how valuations are made by experiment stations, and what are the advantages derived from them, can best be shown, in part, by some extracts from the Connecticut Experiment Station report for 1881.*

First comes a list of prices which are as near as possible to those ruling with standard articles sold at fair prices.

"The average trade-values or cost in market, per pound, of the ordinarily occurring forms of nitrogen, phosphoric acid, and potash, as recently found in Connecticut and New York markets, and employed by the station during 1880, have been as follows:

TRADE VALUES FOR 1881.

(†Table to Show Rather the Relative than Positive Values.)

	Cts. per ℔.
Nitrogen in nitrates	26
Nitrogen in ammonia salts	22½

*By Dr. S. W. Johnson.

†The value of phosphoric acid, nitrogen, and potash, vary according to the sources from which they are derived. The commercial values have decreased very considerably since this table was compiled, but it is reproduced to show the relative values.

Nitrogen in Peruvian guano, fine steamed bone, dried and fine ground blood, meat, and fish, superphosphates, and special manures..20
Nitrogen in fine ground bone, horn, and wool dust................15
Nitrogen in fine medium bone..14
Nitrogen in medium bone...13
Nitrogen in coarse medium bone......................................12
Nitrogen in coarse bone, horn shavings, hair, and fish scrap......11
Phosphoric acid soluble in water....................................12½
Phosphoric acid "reverted" in Peruvian Guano........................ 9
Phosphoric acid, insoluble, in fine bone and fish guano.............. 6
Phosphoric acid, insoluble, in fine medium bone...................... 5½
Phosphoric acid, insoluble, in medium bone........................... 5
Phosphoric acid, insoluble, in coarse medium bone.................... 4½
Phosphoric acid, insoluble, in coarse bone, bone ash, and bone black 4
Phosphoric acid, insoluble, in fine ground rock phosphate............ 3½
Potash in high grade sulphate.. 7½
Potash in low grade sulphate and kainite............................. 5½
Potash in muriate or potassium chloride.............................. 4½

These "trade values" of the elements of fertilizers are not fixed, but vary with the state of the market, and are from time to time subject to revision. They are not exact to the cent or its fractions, because the same article sells cheaper at commercial or manufacturing centres than in country towns, cheaper in large lots than in small, cheaper for cash than on time. These values are high enough to do no injustice to the dealer, and accurate enough to serve the object of the consumer.

To estimate the value of a fertilizer we multiply the per cent. of nitrogen, &c., by the trade-value per pound, and that product by 20. We thus get the values per ton of the several ingredients, and adding them together we obtain the total estimated value per ton."

"The uses of the 'valuation' are, first, to show whether a given lot or brand of fertilizer is worth, as a commodity of trade, what it costs. If the selling price is no higher than the estimated value, the purchaser may be quite sure that the price is reasonable. If the selling price is but $2 to $3 per ton more than the estimated value it may still be a fair price, but if the cost per ton is $5 or more over the estimated value, it would be well to look further. Second, comparisons of the estimated

values and selling prices, of a number of fertilizers, will generally indicate fairly which is the best for the money. But the 'estimated value' is not to be too literally construed, for analysis cannot always decide accurately what is the form of nitrogen, &c., while the mechanical condition of a fertilizer is an item whose influence cannot always be rightly expressed or appreciated."

The excuse for making such copious extracts from Dr. Johnson's report is that the matter is one of importance, as it can be shown that there is a legitimate and effectual method of controlling the prices of commercial manures, so as to keep them within reasonable limits. In most cases, where the price asked for a fertilizer is too large, it is only by a few dollars per ton. Occasionally monstrous frauds are detected. In the report for the Connecticut Experiment Station for 1876, an analysis of one fertilizer is given where the nitrogen it contained was costing the consumers $1.90 per pound, and the phosphoric acid fifty-four cents. Another fertilizer, costing $48 per ton, was found to be worth not far from $13.

What has been written should not prevent any farmer from buying commercial fertilizers because afraid of getting cheated. A much more sensible act is to set about procuring a means of protection. As it is, buy only of reliable parties those fertilizers that have stood the test of examination by our experiment stations. There is no doubt that the compounded fertilizers of some particular firm are generally more costly than when the ingredients are purchased separately and compounded by the farmer.

THE USE OF COMMERCIAL MANURES.

The question, Is it profitable to purchase commercial fertilizers? is a very common one. In attempting a partial answer we shall first make the statement that the profits of raising crops by the use of such manures depend very much upon the kind of fertilizers purchased, and upon the methods adopted in their application. It is hard to understand why the valuable ingredients of plant food, as applied in the manures called commercial, should be any less valuable or effective than when carried to the soil in manures manufactured on the farm. There is no reason why phosphoric acid that is available in a superphosphate should be worth very much more or less than that which is available in the fermented excrement of animals. The same would hold true in comparing nitrogen and potash as contained in the two kinds of manures. But is there no difference between yard manure and commercial fertilizers? Now, so long as farmers must use manure of some kind, and as many buy it, either as made from the excrement of animals or in the form of concentrated fertilizers, an answer to this inquiry is deemed pertinent to the question of the profits resulting from the use of the latter.

1. Farm manures contain all, while commercial fertilizers may contain only a portion of the ingredients which plants use for food. Stable manure can thus be seen to be one that is pretty sure to meet the demands of plants, which is, in one sense, an advantage. But if a farmer were to find it profitable for him to apply large quantities of phosphates to his fields, as is often the case, he would probably get that material more cheaply by purchasing a superphosphate or bone meal, than by getting horse manure from city stables. This would be true, especially if the phosphate and horse manure were valued according to their composition, for, in the case of the latter, the farmer would have to purchase a larger percentage of nitrogen and potash than he desired. It is, undoubtedly, a fact, that if any special ingredient is lacking in a soil, that want can be most cheaply met by purchasing some commercial fertilizer that contains chiefly the substance needed, provided the manure must in either case be bought.

2. The excrements of animals contain a large percentage of organic material that commercial fertilizers do not. This is undoubtedly a point in favor of stable manure, though the carbonaceous compounds of the latter are not needed to supply any deficiencies of plant food. They can furnish only water and carbonic acid, both of which the soil and air can supply in abundance. The chief benefits arising from applying organic

material to any soil results from a change in its physical condition, and from the effecting of a more abundant use of its natural fertility. The addition of decaying vegetable material to the soil often brings about a favorable change in texture and color, while the liberation of so much carbonic acid as comes from the decomposing manure accelerates the disintegration of the soil itself. We have seen how the valuable plant food which is latent in a soil may be made useful through disintegration. These two distinct effects are not to be disregarded when we compare the manures made on the farm with those found in the market, and they constitute a strong argument in favor of the former.

3. It costs more to handle the same amount of plant food in stable manure than in commercial fertilizers. This is obvious when we consider the bulky nature of the former.

Although there are instances of the successful maintenance of the fertility of the soil by the application of commercial fertilizers alone, the basis of good farming consists in the manufacture of manure from the food of cattle. The most profitable use that farmers can make of the fertilizers of the markets, is an amendment to those produced on the farm; as such, they may often be made a paying investment. It is no argument against their use, that the purchasers do not always get their money back. The same would undoubtedly hold true of the purchasing of stable manure in an equal number of cases.

Let us now return to a consideration of what fertilizers to buy and how to use them. The first principle to be laid down is, that a farmer can only buy fertilizers with profit, when he purchases what he needs. What is meant can be illustrated by citing two cases reported by Professor W. O. Atwater:

Chester Sage, Esq., of Middletown Conn., raised corn at the rate of sixty-two bushels per acre, by the application of potash manures costing four and one half dollars, a gain of fifty-one bushels over the corn that had no manure. Superphosphate produced no increase of crop in this case. W. J. Bartholomew, of the same State, found potash useless on his land, while superphosphate caused an increased production of thirteen bushels of corn per acre. Would any sane person sdvise both of these farmers to manure their farms alike? We think not. It is not to be expected, that soils differing in origin and treatment, will each call for the same fertilizer. Practice proves that such is not the case.

Neither are we safe in assuming that the various farm crops should all receive the same kind of manuring. It is not wise to furnish a plant with what it can get for itself. No shrewd farmer would ever think of applying nitrogenous fertilizers to clover, for clover can get its own nitrogen. Plants have different capacities for gathering the various substances they need for food, and we need to recognize this fact.

But some one asks, how am I to discover what my soil and the various crops I grow most need? The answer is: Make a study of your soil and crops; you know about the different fertilizers in the markets, or ought to; you know when you are buying largely of nitrogen, phosphoric acid, or potash, or a mixture of these, at least you should know. Now apply them separately and mixed, and if you are a close observer, you will not fail to discover which application insures you the greatest profit, or if there is any profit in the use of any kind. The chances are, that you will find that one kind has a much better effect on your corn or wheat than another. Do not watch your neighbor, and judge from his results, what you had better do; try for yourself. We have already learned some facts that may serve as hints, nothing more. All other things being equal, save the difference in the crops growing, good results are most likely to follow from the use of nitrogenous fertilizers on grain or grass, potash on potatoes and roots, while phosphates seem in general, to come in well with all crops. Generally, a mixture of the three valuable ingredients, with one or two greatly preponderating, is best. Professor Atwater's efforts have pretty clearly brought out the fact that it does not pay to use much nitrogen in growing corn, but that phosphoric acid and potash, one or both, with a small quantity of nitrogen are generally most profitable.

As before stated, no nitrogen compounds need be applied to

clover, and this doubtless holds true for all leguminous plants, such as peas and beans.

Is it well for farmers to buy commercial fertilizers? The profits of so doing will depend largely upon three conditions:

1. Some reliable guarantee of the quality of the fertilizer bought, should be furnished.

2. Farmers should be sufficiently informed about commercial manures to understand how to buy the ingredients they desire.

3. Farmers should be sufficiently acquainted with the needs of their farm to know what ingredients the soil needs in order to give a profitable increase of any particular crop.

THE PRODUCTION OF FARM MANURES.

No one will dispute the statement that it is an essential thing for each farmer to see that his manure heap attains the maximum in quantity and quality. There should be as much as possible, as good as possible. Farm manures still constitute the basis of successful farming.

THE PRESERVATION OF FARM MANURES.

It is not enough to convert food into manure. The latter must be economically preserved, in order that the best results may be obtained.

How many manure heaps there are that lie exposed in a barn-yard, from which a stream of black water flows after every rain. Do you know, farmer, that the compounds of nitrogen, phosphoric acid, and potash that gives your manure heap the larger part of its value are, to quite an extent, soluble in water and that they can easily be leached out, thereby causing you, indirectly, a loss of dollars and cents?

What more conclusive proof of the above statements do you want than the sight of the luxuriant grass growing in the track of the leachings from the barn-yard. If such leachings could all be taken up by your mowing fields it would be another matter; but very often this is not the case. Dr. Volcker, of

England, carried on an investigation that led to a satisfactory demonstration of the effect of exposure and leaching upon a heap of yard manure. He exposed manure under four different conditions, and by weighing and analyses at stated periods was able to take account of the changes and loss that were taking place. The manure was submitted to the various conditions for nearly a year, which were as follows:

No. 1. Fresh manure exposed in a heap against a wall.
No. 2. Fresh manure kept under a shed.
No. 3. Fresh manure spread in open yard.
No. 4. Well-rotted manure exposed in a heap against a wall.

When the manure was first placed under the above-named conditions, it was weighed and analyzed, and during the year's time that it remained where it was placed, was weighed and analyzed four more times, in order to discover the changes that were going on. In the following tables are given the dates at which the weighings and analyses were made, the composition, and the percentage of loss by weight:

The manure was first exposed to the various conditions November 3, 1854.

No. 1. Fresh manure exposed in a heap against a wall:

	Nov. 3,	Feb. 14,	Apr. 30,	Aug. 23,	Nov. 15,
	1854.	1855.	1855.	1855.	1855.
Water	66.17	69.83	65.95	75.49	74.29
Soluble organic substance	2.48	3.86	4.27	2.95	2.74
Soluble inorganic substance	1.54	2.97	2.86	1.97	1.87
Containing nitrogen	.149	.27	.30	.19	.18
Per cent. of loss in weight			28.6	29.7	30.4

No. 2. Fresh manure kept under a shed:

	Nov. 3,	Feb. 14,	Apr. 30,	Aug. 23,	Nov. 15,
	1854.	1855.	1855.	1855.	1855.
Water	66.17	67.32	56.89	43.43	41.66
Soluble organic substance	2.48	2.63	4.63	4.13	5.37
Soluble inorganic substance	1.54	2.12	3.38	3.05	4.43
Containing nitrogen	.149	.17	.27	.26	.42
Per cent. of loss in weight			50.4	60.0	62.1

No. 3. Fresh manure spread in open yard.

	Nov. 3,	Feb. 14,	Apr. 30,	Aug. 23,	Nov, 15.
	1854.	1855.	1855.	1855.	1855.
Water	66.17		80.02	70.09	65.56
Soluble organic substance	2.48		1.16	.49	.42
Soluble inorganic substance	1.54		1.01	.64	.57
Containing nitrogen	.149		.08	.06	.03
Per cent. of loss in weight			13.04	38.07	42.4

No. 4. Rotten manure exposed in a heap against a wall.

	Dec. 5,	Feb. 14,	Apr. 30,	Aug. 23,	Nov. 15,
	1854.	1855.	1855.	1855.	1855.
Water	75.42	73.90	68.93	72.25	71.55
Soluble organic substance	3.71	2.70	2.21	1.50	1.13
Soluble inorganic substance	1.47	2.06	1.68	1.10	1.04
Containing nitrogen	.297	.149	.14	.09	.09
Per cent. of loss in weight			26.50	36.5	37.8

These tables need studying in order to get at the facts they teach. The tendency of farm manure in fermenting is to lose weight, and to increase its percentage of soluble material. If no leaching takes place this soluble material will accumulate in the heap, that is, the heap will become more concentrated in soluble matter. This is seen to be the case in the pile of manure kept under a shed. Of the fresh manure kept out of doors that in the heap suffered least. The heap that was rotted in the start suffered more than the fresh. It is to be noticed that the manure kept under a shed lost considerable in weight, but the loss was largely in water which dried out, and in carbonic acid which resulted from the combustion going on in the heap. A little calculation shows that there was more soluble nitrogen in the covered pile at the end of the year than at the beginning, while in all the other samples of manure there was considerable loss, not only of nitrogen but of other valuable material. The following table may be interesting in showing the relative actual loss of organic material and nitrogen by keeping manure under various conditions, also in giving a hint as to whether there is a loss in fermenting manure under favorable conditions. If any valuable ingredient were to be lost from manure decomposing under a shed, it would be nitrogen.

		Total quantities of organic matter and nitrogen in manure at beginning of experiment, November 3, 1854.	Total quantities of organic matter and nitrogen in manure at end of experiment, November 15, '55.	Percentage of loss of organic matter and nitrogen by the various methods of keeping the manure.
		Pounds.	*Pounds.*	*Per cent.*
No. 1.	Organic matter,	801	268	66.6
	Nitrogen,	18.2	13	28.5
No. 2.	Organic matter.	919	408	55.5
	Nitrogen,	20	18.8	6
No. 3.	Organic matter,	466	98	78.6
	Nitrogen,	9.5	3.9	59
No. 4.	Organic matter,	266	135	49.2
	Nitrogen,	9.8	6.6	32.7

Are not these figures sufficiently striking to induce a careless farmer to exercise some care in preventing loss from his manure heaps? Only six per cent. of nitrogen was lost when the manure was covered, and fifty-nine per cent. when it was spread out and allowed to leach. Even when in a heap out of doors thirty per cent. nearly of the nitrogen was lost. There is no reason to doubt but that a corresponding loss occurred with the valuable mineral ingredients, from the careless management.

Again, there is often a careless waste of the urine.

Now, the liquid excrements are valuable. We have seen that all the nitrogen compounds which pass through the processes of digestion and are not used by the animal, pass out in the urine. The potash goes out in the same channel, while the phosphoric acid is retained with the solid excrement. The manurial ingredients of the liquid excrement are more valuable, pound for pound, than those of the same kind existing in the solid. Then why not save them?

Until farmers avoid the wastes incurred in the two ways mentioned above, let them not complain of hard times or the barrenness of their fields. What foolishness, also, to buy commercial fertilizers and pay for what might be obtained much more cheaply by the exercise of a little care!

What is the best method of preserving manure? Use plenty of absorbents, unless you have water-tight tanks in the barn cellar. Dry loam and muck, when they can be used, are better for absorbents than straw, for the reason that strawy manure cannot easily be distributed in the soil in an even and finely divided condition. Have a good barn cellar, with water-tight tanks, if possible; if not, then build a manure shed. In the latter case, or if the manure *must* be thrown into an open yard, have the floor beneath the cattle water-tight, so that all the liquid can be taken up by the absorbent used.

Some suggestions with reference to the differences of treatment demanded by the manure from the different farm animals, may not be amiss. It is well known to farmers that horse and and sheep manure, under certain conditions, are very liable to ferment so rapidly as to get hot. When this occurs the manure grows white, and seems to have been burned. The question is often asked, does it cause any loss to have such a thing happen? We answer, yes. Almost the entire amount of nitrogen in a heap of manure may thus be driven out largely in the form of ammonia. The reason why horse manure "heats" so much more readily than that from cows, is, that it is coarser and not so wet. This coarseness allows a free circulation of air through the heap, while the dryness admits of a more raipid rise of temperature than would be possible if it contained more moisture. A larger amount of water would also increase the capacity of the manure to absorb and retain the products of decomposition. The more compact and moist a pile of horse manure can be kept, the less danger there is of loss from heating. It is an admirable plan to throw the excrements of horses and cows together, where they can become thoroughly mixed, the mutual effect of the two kinds upon one another causing a saving in the case of the one and an increased activity of the other. The manure of sheep had better be trodden under their feet, to lie in a compact condition until about the time it is used.

THE TREATMENT AND APPLICATION OF FARM MANURES TO THE SOIL.

The questions most commonly asked in regard to how to treat and use farm manures, are:

(1) Is it better to ferment manure or apply it green? and

(2) When it is applied, is top dressing, or working manure into the soil, the better method?

In answering the first inquiry, let us first consider the differences between rotted manure and "green" manure.

When the excrements first come from the animal, the manurial ingredients, especially in the undigested portions or solids, exist in the same form that they did in the plant. Now, one plant, unless parasitic, can not feed upon the material that exists in another until such material has undergone certain changes. In order that the ingredients contained in vegetable fabric may become plant food, a decomposition must take place. The phosphoric acid needs to be liberated from its organic combinations, and the nitrogenous substances in the vegetable material must be broken down so that the nitrogen can be converted into ammonia and nitric acid. When manure is rotted there occurs a partial, and, to some extent, a complete breaking down of the vegetable compounds in the excrements, and an additional decomposition of the substances in the urine, which are chiefly the result of a previous partial breaking down of the albuminoids in the animal.

While but little ammonia and nitric acid may be formed in fermented manure, the decomposition that has taken place has carried the valuable ingredients of the fresh excrements quite a long distance in the direction of the forms into which they must finally come in order to serve the purposes of the plant. Consequently, rotted manure can more quickly produce a vigorous effect upon growing crops than that which is fresh.

But the question of the availibility of the plant food in stable manure at the time it enters the soil is not the only one that must be considered. It is essential for us to know whether, in fermenting manure, or in making its nitrogen, phosphoric acid, and potash more available to plants, there is not a loss of these

substances. Again, is there reason for believing that any beneficial effects result from having the manure go through its chemical changes while in contact with the soil rather than before it is applied to the land?

As to the matter of loss from fermenting manure, we will again refer to the table showing the results of Dr. Volcker's investigations where he found that only six per cent. of nitrogen was lost from the manure fermented under a shed. It is safe to assume that there would not be an appreciable loss of the mineral ingredients of animal excrements during the process of decomposition provided no leaching takes place.

Manure fermented under proper conditions doubtless does not suffer a very large loss. And by proper conditions is, the keeping of the heap moist after the excrements have received a mixture of absorbents. If manure be allowed to rot, great care should be taken to secure a complete absorption of the products of decomposition, and to this end it should not be too rapid and should be accompanied by moisture. With manure largely from concentrated food, there is no doubt but that the use of absorbents tends especially to insure against loss from the chemical changes that take place. Granting that rotted manure is more efficient at first, and can be obtained without much loss, it is to be said on the other hand that the excrements of animals can not be put through a thorough process of decomposition without involving an extra expense, and this is especially true of manure treated so as to ferment without loss. The factor of expense must be allowed.

The other question to be considered is that of the benefit coming from having the manure go through the chemical changes necessary to convert it into plant food, when in contact with the soil. Although it is to a certain extent still a matter of theory, yet we have no doubt but that the decomposition of stable manure after it is mixed with the soil causes an increased disintegration of the latter.

Previous figures show the large amounts of inert plant food that may exist in even run-out fields. When we have brought this into a condition for plants to use we have added so much more to the capital applied to our farming operations. Our soils are still a store-house of plant food, and there is every reason to believe that the decay of the organic material of animal excrements after its application to the land is an efficient agent in forcing into service the inactive mineral substances.

The practice of top dressing as compared with working manure into the soil, is one of importance. And here we can not appeal to definite results to establish the correctness of either method of practice. There is not the slightest doubt but that so far as theoretical arguments are concerned, they are strongly against top dressing. This is especially true if horse manure be the one used. By putting fresh manure on the surface of the land we lose the good effect that would result from its decomposition in the soil, we stand in danger of a certain amount of loss of manurial value, and when the manure is in a coarse, lumpy condition, as it is likely to be when not rotted, we get a poor distribution and slow returns. Do not say that it costs something to mix with the soil. Cultivation pays for itself in the greater utilization of the natural fertility of your fields.

Nevertheless, in spite of the weight of evidence furnished by theory, we are not prepared to assert that top dressing is always less profitable than some other method of applying manure. We are waiting for accurate facts.

It is not claimed that this paper approaches anything like completeness as a presentation of the facts bearing upon the fertilizing of land. It does contain facts enough, when heeded, to greatly improve the condition and profits of agriculture.

The sole object of agriculture is the production of such plants as contribute to the satisfaction of the wants of mankind. The soil constitutes a magazine of the materials of crop production. The whole range of vegetable production embraces fourteen elementary substances; but not all of these fourteen are necessary to every species, nor to the same species under all circumstances. All of these substances are to be found in all soils in various forms and degrees, and all except Phosphoric acid, Nitrogen and Potash in quantities practically inexhaustable.

It is the business of the farmer, by the various processes of cultivation, to combine these several elements in the production —or as we might not improperly say—manufacture of such crops as he proposes to make. Every plant is its own chemist, with the soil for its laboratory, and may be implicitly trusted to take care of itself, if the materials in a condition suitable to serve as food are placed within the reach of its roots. The amount of the several elements that are withdrawn from the soil by the plant are exactly represented by the crop, just as a piece of cloth represents the cotton, or other material out of which it is made.

The first inquiry which addresses itself to the farmer who proposes to increase the product of his land by the use of fertilizers is, what is the most economical means of effecting this object.

The great competion in all industrial pursuits,—and in farming not less than in others—has narrowed the margin for profits to such an extent as to render success dependent upon judicious, and especially upon the economical employment of means. Thrift in farming will be found largely dependent upon the use of home-made fertilizers; chief among which is barn-yard manure. This can be most easily and economically applied after having been composted with such other waste material as may be available.

The efficacy of barn-yard manure depends upon precisely the same elements as are offered to the farmer in the various chemical fertilizers—the chief constituents in all being Phosphoric acid, Nitrogen and Potash. These three elements are required by different crops and different soils in very different proportions. Whilst they are all present in barn-yard manure, yet they exist in proportions very different from that in which they are required by the several crops which are most commonly produced with us. The amount of phosphoric acid in a ton of this manure varies from 3 to 4 pounds per ton. The amount of ammonia (or nitrogen) varies from 8 to 10 pounds per ton. Cotton, for instance, requires a fertilizer in which phosphoric acid largely preponderates, so that in order to get as much phosphoric acid as is needed we would have in using barn-yard manure, to apply an amount of ammonia, which would not only be extremely wasteful but also very injurious to the crop. These disproportions should be corrected by composting, adding to the manure the necessary quantity of the required chemicals; most commonly acid phosphate. It is unquestionably best for many reasons to compost our home manures with cotton seed meal and such chemicals as may be requisite to adapt them to the needs of the several crops to which they are to be applied, but should this not have been done, and it is to be applied in a crude condition, the question arises as to the best method of using it,—whether by top-dressing or plowing under.

Upon this question some observations will be found in another part of this article.

CHEMICAL ANALYSIS OF SOILS *

"Was the first step in the attempt at rational manuring. Years ago it was universally believed that a chemist could analyze a soil, find out its defects and apply the proper remedial manures. There are many who still entertain this belief, if we may judge from the large number of enquiries of this character that are received by this department. A chemical analysis can give you negative results when they exist; it can tell you when there are very small amounts of the chief ingredients in the soil. It can expose abject poverty or sterility, but it can not absolutely reveal its deficiency in plant food. The chemist can give you the exact composition of your soil—how much phosphoric acid is present, but he can't tell you when it will be available—whether your plants will get the benefit of it the next year, the next decade, or the next century, is entirely beyond his ken. But a thorough chemical investigation of a series of soils, whose natural growths and agricultural capacities are known, will throw a flood of light upon the subject, and may suggest, by a tedious comparison of the

* By Prof. Stubbs.

composition of known infertile soils, with those of acknowledged fertility, some treatment by which the former may be made productive. But such an investigation would be expensive, tedious and at best limited in its application, since many fields contain several different kinds of soils, and the soluble plant food of to-day becomes the insoluble rock of to-morrow, and *vice versa.* Again, there are many and various factors which enter into the solution of the problem of plant life which no chemist can reveal, and hence soil analyses valuable in themselves when used by comparison and properly interpreted by agricultural chemists, can not be used for establishing fixed formulas for fertilizers.

PLANT ANALYSIS

Was next invoked as furnishing a more satisfactory guide to proper manuring. If we take the entire crop grown upon an acre and find out by chemical analysis the exact amounts of each ingredient which make up its composition, we know the materials removed from the soil by this crop. In this way tables of great practical benefit have been calculated for given amounts of certain crops per acre. For example a crop of twenty-five bushels of corn per acre with stalks, fodder, shucks, cobs and roots removes from the soil thirty-eight pounds of nitrogen, twenty pounds phosphoric acid, thirty-six pounds potash, twelve pounds magnesia, fourteen pounds lime, and four pounds sulphuric acid. Supposing the soil supplied magnesia, lime and sulphuric acid in abundance, then we would have to provide thirty-eight pounds nitrogen, twenty-six pounds phosphoric acid, and thirty-six pounds potash in readily available forms, in order to supply the draft made upon the soil by the corn. We could not only furnish the above ingredients in as cheap a form as could possibly be obtained, by the following formula, but also all the magnesia, lime and sulphuric acid needed. The following ingredients in the formula, are worth at our interior markets the following prices:

Cotton Seed Meal,	per	ton,	$20.00.
Acid Phosphate	"	"	$20.00.
Kainite	"	"	$15.00.

Our formula would be: 550 pounds cotton seed meal, 200 pounds acid phosphate, 300 pounds kainite, and would cost $9.75 per acre. Even if this formula were sure to yield twenty-five bushels per acre it would be a costly application to many farmers of our State. But need we use all these ingredients? May not our soil hold large contents of nitrogen which this crop can utilize? May not potash be abundant in available forms, or if not available, may not the gypsum present in every acid phosphate, and which tends to liberate potash from its insoluble combinations, soon make it so? Eliminating all the potash and a part or the whole of the nitrogen from our formula, reduces greatly the cost of our fertilizer and on a large farm would constitute quite a profit. The defect of every formula built upon plant analysis, is the ignoring of the plant food in the soil and the feeding capacity of different plants. Concurrent testimony of the field and laboratory shows that different soils fnrnish unequal amounts of plant food, and that different kinds of plants possess very unlike capacities for extracting this food. Hence a division of plants according to this power has been adopted. Cereals will not thrive on poor soils. Cowpeas will. Turn a growth of the latter in, either green or after it has decayed and now your cereals will grow. The pea gets nitrogen, while the cereal will fail for the want of it. Nitrogenous manures are of little or no benefit for peas while it is everywhere used in large quantities for small grain and this, too, notwithstanding the fact that our cow pea contains a great deal more nitrogen than the cereals. Peas, by virtue of their deep tap roots, are gross feeders, extracting their food from great depths, while cereals with their fibrous surface roots, delicately organized, must find their food ready formed in the upper layers of the soil. Cereals containing by analyses but small proportions of nitrogen, on account of the large amount of this ingredient necessary to grow them, are called nitrogen plants, while cowpeas, clover, &c., are classed among the mineral plants. We can then assert that the composition of a green crop does not fnrnish the exact quantities of fertilizing ingredients which will best help its growth. This simple plan of

fertilizing plants is attractive and costly and a large number of formulas for different crops have been constructed in accordance with this idea by leading scientists in every country. Being purely rational, many farmers have been captivated into their use—sometimes with profit, sometimes with loss. It is far better than using featilizers at random, as is always done in every country where commercial fertilizers are at first introduced, but it is wasteful in the highest degree.

DIVIDING CROPS INTO CLASSES

according to their predominent ingredient, and making formulas for each class was the next advance in scientific manuring.

For general and indiscriminate use, covering a large amount of territory, where character of soil, and special factors of growth, such as climate, rainfall, heat cultivation, etc., are either unknown or, if known variable between wide limits, it is to be highly recommended. Of course this plan ignores the amount of plant food which a soil can furnish. It assigns to the soil, the German definition "as a place simply to hold manure" and omits the fact that it may, under proper culture, furnish many of the necessary ingredients contained in the fertilizer. Soils vary in their composition according to origin, if from feldspathic granite they contain a large amount of potash. If from sedimentary rocks of animal origin, lime with perhaps a small quantity of phosphoric acid, will be present. If of alluvial formation, nitrogen may be abundant. Every soil has its ingredients in different proportions and where our richest soils may have them all in quantities to grow maximum crops for many years, sooner or later one or more elements will be exhausted or so depleted as to check the growth of large crops, while the others will still be present in available forms and large quantities. The application of a manure containing this one ingredient would then only be necessary to maintain its primitive fertility. To apply a complete manure, one containing all the valuable ingredients, to these soils, is an apparent waste, hence even this plan, commendable as it is, for general use, is waste. It loses sight of the "natural strength" of a soil and applies manure with reference only to the feeding capacity of the plant cultivated. To successfully manure we must keep constantly in view, both the natural strength of our soils, and the feeding capacity of our plants. The latter, is for most of our cultivated crops, pretty well determined, but the former can only be decided by

EXPERIMENTS,

hence experimentation is now regarded as the only rational method of determining the exact kinds of fertilizers needed by our soils. Variations in the composition of soils, suggest the impropriety of entirely accepting the results obtained by experiments in one locality in a State or county as being applicable to every other part. It forces every farmer to experiment for himself, and in doing so, causes him to spend much time in wholesome reflection and study which must result in the acquisition of valuable knowledge. Again, could all of our farmers be induced to try yearly a series of carefully conducted cheap inexpensive experiments and report the results, what an immense aggregate would be added to our agricultural knowledge, to say nothing of the thousands of dollars annually saved in the proper use of fertilizers, and the increase in the prosperity of the country.

A spirit of experimentation has been manifested by many of our progressive farmers scattered all over this State during the past year, and seems to be on the increase. Hence a series of simple experiments are given below, and each farmer is earnestly requested to give them a trial, in order to determine for himself, whether his fields need nitrogen, phosphoric acid or potash. Select as near as possible a plat, representing the true character of the field. Lay off rows of uniform width and length, and take three to each experiment. These rows should be of such a length as to make the experiment of three rows equal to one twentieth of an acre. Let there be six experiments.

Upon the 1st three rows, apply 10lbs Cotton Seed meal.
" " 2nd " " " 10lbs Acid Phosphate.
" " 3rd " " " 10lbs Kainite.

Upon the 4th three acres apply Nothing.
" " 5th " " " { 10lbs Cotton Seed meal. 10lbs Acid Phosphate. }
" " 6th " " " { 10lbs Cotton Seed meal. 10lbs Acid Phosphate. 10lbs Kainite. }

No. 1 will tell you whether your soil needs nitrogen only.

No. 2 will answer the same question relative to phosphoric acid.

No. 3 responds as to potash.

No. 4 gives you "natural strength" of your soil.

No. 5 gives results of combination of nitrogen and phosphoric acid.

No. 6 gives results of combination of nitrogen, phosphoric acid and potash.

If the above be conducted through several years on same field, and similar results be obtained each year, information of great value will be obtained by the experiment. I have used the above substances because they are the cheapest and most accessible, and the superiority of their ingredients in these forms over any other to be found in our market, has been demonstrated by a large number of experiments, both in corn and cotton. Cotton seed meal is especially adapted to our climate, and, as a source of nitrogen, has no superior. It contains, besides, small quantities of phosphoric acid and potash. The soluble phosphoric acid in acid phosphates, on the soils of East Alabama, has been found superior to the reduced and insoluble, and we believe it will be so found everywhere in the South, where clean culture has prevented an accumulation of vegetable matter in the soil. This experience is not at variance with that obtained in other countries. Wherever the soils contain much vegetable matter, reduced and even insoluble phosphoric acid may be found highly beneficial, and the use of soluble phosphoric uneconomical. A phosphate found in France, containing too little phosphoric acid to be profitably treated with sulphuric acid, has long been known to give little or no immediate results when applied finely ground to various loamy or sandy lands, but on soils rich in humus it has produced striking results. The late Dr. Ravenel, of Charleston, S. C., found the finely gound phosphate readily available to certain kinds of plants when applied in conjunction with a large crop of cow peas. Recent experiments have shown that swamp muck or peat, when thoroughly mixed with small quantities of ground phosphate, and well moistened with water, has the power of bringing them in solution. These and other experiments show that the reduced and insoluble phosphates are made available to plants by the acids of decaying vegetation. In the North, where cereals, grasses and roots are the main crops, and where the soils are filled with vegetable matter, the reduced, and even the finely ground insoluble phosphates, are often used with excellent results. But our conditions are very different. We have been fighting grass for years; the clean culture demanded in growing cotton, has prevented an accumulation of humus in our soils, and our long hot summers oxidise it much more rapidly than further north. Hence most of our soils are very deficient in humus, and upon them, we believe, only acid phosphates containing a large amount of soluble phosphoric acid should be used. Therefore, in buying acid phosphates, especially for cotton, every farmer should be careful to obtain those containing the largest percentage of soluble phosphoric acid.

I have recommended above the use of cotton seed meal. This is done, with the belief, derived from a series of experiments, that it is fully the equal of cotton seed as a source of nitrogen. Cotton seed should never be used as a fertilizer until its oil, which has no fertilizing property whatever, is extracted. If all of our seed, over and above what is required for planting, could be passed through a mill for the extraction of its oil, and the latter put upon the markets, it would represent a large wealth which is now annually buried. As yet but little inducement has been offered the farmer to exchange his seed for meal. Most of the seed now used by the oil mills are purchased outright and the products rarely return to the farm from which the seed was taken. In every instance, if the seed

go to a mill, the meal and hulls, particularly the former, should be returned to the farm. Our Southern farmer should buy little or no nitrogen. With proper care and utilization of manure from our domestic animals, added to our cotton seed, we should have enough to grow all our present crops. Under no circumstances should either stable manure or cotton seed be used alone under cotton, under corn and small grain, it is permissible but not advisable. They should both be

COMPOSTED

with acid phosphate and kainite when experiments have demonstrated the necessity of potash. The compost is the best manure for all crops, is now the verdict of nearly every one who has used it. There is a power in the combination, a strength in the mixture, a ferment in the union which multiplies roots, enlarges foliage and increases the fruit. The compost prepared differently for each class of crops, not only economizes and properly utilizes the waste products of our farms but serves to develop the powers of observation and thought of farmers. Commercial fertilizers should be avoided till the compost is exhausted and then bought only when its guaranteed constituents are known to be adapted to our soils and plants.

All composts should be made under shelter and well protected from the weather. In making compost an abundance of water should be used—in fact the cotton seed should be thoroughly saturated with it, and then subsequent danger from firefanging is avoided. It should remain up at least six weeks and longer if possible. Layers of stable manure and cotton seed should not be over three or four inches thick. I give below the proportions which have been found best adapted to the different crops.

FOR WHEAT.

400—500 bushels stable manure.
400—500 " cotton seed.
1 Ton acid phosphate.

FOR OATS.

300—400 bushels stable manure.
300—400 " cotton seed.
1 Ton acid phosphate.

FOR CORN.

200 bushels stable manure.
200 " cotton seed.
1 Ton acid phosphate.

FOR COTTON.

100 bushels stable manure.
100 " cotton seed.
1 Ton acid phosphate.

If your lands need potash, ½ ton of Kainite may be used in each formula. In using Kainite dissolve it in water and use the latter in wetting your compost. If cotton seed meal is preferred in place of compost, use at the rates of one ton for each 100 bushels of cotton seed and 100 bushels stable manure given in the formula, retaining the same amounts of acid phosphates and kainite."

---

*THE COTTON PLANT AND ITS PRODUCTS.

The fact has been thoroughly and practically demonstrated that by a careful husbanding of home manures, three-fourths of the money usually expended in the purchase of commercial fertilizers may be retained in the pockets of the farmers without any diminution of the crops produced.

Yet, while spending their hard-earned money for commercial fertilizers, they are guilty of the most extravagant waste of these home materials. There is no country in the world more fruitful in the production of home manures than one in which cotton is the staple product; nor is there any in which so little

*From the Farmers' Scientific Manual of Georgia Agricultural Department; prepared by Prof. White.

plant-food is sold from the farm. On a farm on which cotton is the staple product, only 2¾ pounds of plant food are sold from the average Georgia acre, while 97 are returned to the soil in the plant and the seed, as shown by the following analysis of the cotton plant by H. C. White, Professor of Chemistry in the University of Georgia:

Under the head of

"THE CHEMISTRY OF THE COTTON PLANT,"

Prof. White says: "The cotton plant, as it stands in the field ripened and ready for picking, may be divided into six parts: the lint, seed, bolls, leaves, stem and roots. An average plant, air dried, may be assumed to weigh 3.5 ounces.* Of this:

The lint will weigh	0.3 ounces.
The seed will weigh	0.6 ounces.
The bolls will weigh	0 5 ounces.
The leaves will weigh	0.5 ounces.
The stem will weigh	1.3 ounces.
The roots will weigh	0.3 ounces.

"In producing an average crop of 150 pounds of lint cotton per acre, there will have been grown on the acre 150 pounds lint, 300 pounds seed, 250 pounds bolls, 250 pounds leaves, 600 pounds stem, and 150 pounds roots.

	Organic matter.	Mineral matter or ash.
The lint consists of, (in 100 parts)	98.25	1.75
The seed consists of (in 100 parts)	96.59	3.41
The bolls consists of, (in 100 parts)	85.24	12.96
The leaves consists of, (in 100 parts)	82 74	15.22
The stem consists of, (in 100 parts)	95.02	3.98
The roots consists of, (in 100 parts)	92.76	5.08

"The organic matter consists, in all cases, of oxygen, hydrogen, carbon and nitrogen. The different portions of the plant contain in 100 parts the following respective amounts of nitrogen:

Lint	0.54
Seed	1.96
Bolls	1.03
Leaves	2.14

*An average obtained by actually weighing a number of plants carefully air dried, such as would probably produce the assumed average crop of 150 pounds per acre.

Stem	1.16
Roots	1.17

"The ash of the lint will contain in 100 parts:

Phosphoric acid	10.25
Potash	21.34
Lime	26.74
Magnesia	9.46
Other mineral matter	32.21

"There will be contained in one hundred parts of the ash of

	Seed.	Bolls.	Leaves.	Stem.	Roots.
Phosphoric acid	35.76	6.87	7.75	13.68	7.50
Potash	30.25	14.28	14.96	24 06	23.52
Lime	9.87	27.31	28.14	26.36	23.37
Magnesia	12 42	6.14	6.11	9.75	8.23
Sulphuric acid	6.48	13.25	12.97	5.52	4.12
Oxide of iron	1.87	5.12	5.60	1.41	6.68
Chlorine	.85	4.11	4.65	6.42	8.01
Soda	2.50	8.84	9.25	6.79	10.64
Silica	—	14 08	10.57	7.01	8.63

"In reviewing these results, we observe that the most important mineral constituents in each and every part of the cotton plant are phosphoric acid, potash, lime and magnesia. In round numbers, we have in 100 parts of the ash of each part of the plant, the following amounts of these main constituents:

"In 100 of the ash of

	Lint	Seed.	Bolls.	Leaves.	Stem.	Roots.
Phosphoric acid	10	36	7	8	14	8
Potash	21	30	14	15	24	24
Lime	27	10	27	28	26	22
Magnesia	10	12	6	6	10	8

"Estimated from these percentages and the proportion of ash before stated, as yielded by the several parts of the plant, we have in 100 parts:

	Lint.	Seed.	Boll.	Leaves.	Stem.	Root.
Phosphoric acid	0.18	1.22	.91	1.22	.56	.40
Potash	0.37	1.02	1.82	3.28	.96	1.22
Lime	0.48	.34	3.49	4.25	1.04	1.12
Magnesia	0 17	.41	.77	.92	.40	.41
Nitrogen	0.54	1.96	1.03	2.14	1.16	1.17

"As before stated, in producing an average crop of 150

pounds of lint cotton per acre, there will also have been produced 300 pounds seed, 250 pounds bolls, 250 pounds leaves, 600 pounds stems and 150 pounds roots.

"There will be contained in

	150 lbs. lint.	300 lbs. seed.	250 lbs. bolls	250 lbs. leaves.	600 lbs. stems.	150 lbs. roots.
Pounds phosphoric acid	0.27	3.66	2.26	3.05	3.36	0.60
Pounds potash	0.54	3.06	4.52	8.20	5.76	1.83
Pounds lime	0.72	1.02	8.82	10 60	6.24	1,68
Pounds magnesia	0.24	1.23	1.93	2.30	2.40	0.61
Pounds nitrogen	0.81	5.88	5.07	5.35	5.96	1.75

"To sum up, therefore, we find that to produce the above stated average crop of lint cotton per acre, there would be required in all:

Phosphoric acid	13 pounds.
Potash	24 pounds.
Lime	30 pounds.
Magnesia	9 pounds.
Nitrogen	26 pounds.

"The bolls, leaves, stem and roots are usually returned at once to the soil, and with them is returned in round numbers:

Phosphoric acid	9 pounds	Magnesia	7 pounds.
Potash	20 pounds	Nitrogen	19 pounds.
Lime	27 pounds.		

"Of the remainder, there is left in the gin-house, with the seed:

Phosphoric acid	4 ponnds	Magnesia	1 pound.
Potash	3 pounds	Nitrogen	6 pounds.
Lime	1 pound.		

"Whilst there is entirely removed from the acre, and sent into market with the lint:

Phosphoric acid	¼ pound	Magnesia	¼ pound.
Potash	½ pound	Nitrogen	1 pound."
Lime	¾ pound.		

Let us now examine the analyses of one of the principal cereals and see how the quantity of plant-food removed in this from an average acre of land compares with the above.

Since a larger proportion of the grain of wheat is removed from the farm than of any other cereal, it will best illustrate the point in hand. As the straw and chaff are generally returned in some form to the soil, they are omitted in the calculation of the quantity of plant-food removed from the farm.

Assuming ten bushels as the average yield per acre—a fair assumption for grain growing regions—a calculation on that basis from analysis of Wolff and Knop shows the following quantities of the principal elements of plant-food are removed in every ten bushels of wheat sold from the farm, compared with that removed in lint from an average acre in cotton:

	Wheat.	Lint cotton.
Nitrogen	12.40 pounds	1.00 pounds.
Potash	3.30 pounds	.50 pounds.
Lime	.36 pounds	.75 pounds.
Magnesia	1.40 pounds	.25 pounds.
Phosphoric acid	4.90 pounds	.25 pounds.
Total	32.36 pounds	2.75 pounds.

This represents a most remarkable contrast between the exhausting effects of wheat and cotton in the amounts of the elements of plant-food removed by sale from the soil, and yet the cotton soils are being more rapidly exhausted than those on which wheat is the principal stale produced for market.

These seem to be contradictory facts which demand explanation.

The apparent contradiction arises from the existence of other factors which are operative to a greater extent in aid of exhaustion on the cotton than on the wheat farm.

In wheat growing regions the soil is not denuded of vegetable matter during the leaching rains of winter and spring, but is protected, either by small grain or grass, from surface washing. The summer fallow, in the preparation for seeding wheat, necessarily returns more or less vegetable matter to the soil, and with it not only mineral elements of plant-food, derived from the soil in an available form, thus returning, in an improved condition, all that the plants turned under have taken from the soil, but this return is augmented by whatever organic matter the plants have extracted from the atmosphere. Not only are more stock kept, and consequently more animal manure produced, but more attention given to its collection, and more

care taken to protect it from the injurious effects of leaching and evaporation. It will thus be observed that while much plant-food is removed in the produce sent to market, but little is wasted of the natural manurial resources of the farm.

On the cotton farm, the fields are left bare after the crops are gathered, and exposed throughout the winter to leaching and washing action of the rainy season. A single heavy rain in winter or early spring, when the surface is finely pulverized by recent freezes, often causes greater injury to the naked fields of the South than would the removal of a dozen crops of lint cotton. This could be prevented by sowing oats or rye at the last plowing of the cotton, or in August or first of September, even *without plowing* them in, leaving them to germinate under the influence of the equinoctial rains. These would serve the double purpose of protecting the land from waste during the winter, and of furnishing a green crop to be turned under in the preparation of the soil for the spring crops. The denudation of soils of vegetable matter, by clean culture and the absence of any system of rotation of crops, is a fruitful source of the rapid exhaustion of Georgia soils. The waste of natural manurial agencies on Southern farms is without a parallel. Cotton seed are "thrown out to rot," where they are robbed alternately by the leaching rains and the drying winds, until much of the soluble plant-food is lost. Mules and cattle are fed in unsheltered lots, where fully one-half of the soluble parts of their manure is washed into the adjacent streams or passes off into the air under the influence of the winds and the sun.

Cotton farms, therefore, have not been exhausted by the removal of plant-food in the sale of their products, but by exposure to winter rains, by the waste of home manurial resources, and the absence of a system of rotation by which the soil is supplied, periodically, with a sufficiency of vegetable matter.

It is gratifying to be able to say that there is a growing disposition to adopt a more rational and self-sustaining system of farm economy. Home manures are being more carefully husbanded and the compost system being generally adopted, as recommended in the circulars of the department.

COMPOSTING SUPERPHOSPHATES WITH HOME MANURES.

When we consider the fact that the farmers of Georgia expended about *four millions* dollars last season for fertilizers, even on a cash basis, the question of the most economical mode of permanently improving our soils, and at the same time producing remunerative crops, is one of vital importance to our people.

The Philosophy of Composting.—Stable manure is admitted on all sides to be a complete manure, in the sense of containing all of the necessary elements of plant-food. There are some of the more important elements (phosphoric acid is the principal) which are contained in such small percentage, that large quantities of the manure must be applied in order to secure a sufficient quantity of this essential element for the necessities of plant sustenance. To supply this deficiency, superphosphate is added to the compost heap. A combination of stable manure and cotton seed, in the proportions recommended, supplies enough ammonia for summer crops, but hardly sufficient for winter small grain, unless applied at the rate of 400 pounds per acre. The sulphate of lime contained in every superphosphate, besides being otherwise valuable as a chemical agent, serves to fix the ammonia generated in the progress of decomposition in the compost heap. The fermentation reduces the coarse material, and prepares it for the use of the plant.

"*Composting in the Ground.*"—This is advocated by Prof. Pendleton and others, and as far as results on crops are concerned, is satisfactory, but has some serious objections in practice. If cotton seed are used, they must be put into the ground before warm weather commences, to prevent germination. This necessitates stirring the manure just before planting, which would risk bringing some of it to the surface, or the crop must be planted on a hard bed. Another difficulty under the general practice in Middle and Southern Georgia, is that stock would have to be taken out of the field before spring. This would be advantageous to the land, but would give the planter some inconvenience. There is no labor saved by this system, but it is applied at a season of comparative leisure.

Composting Under Shelter.—This may usually be done on rainy days, or when the ground is too wet for the plow, so that little time need be lost by the manipulation of the heap. There are two methods practiced with equally satisfactory results:

One is to apply the different ingredients in successive layers, and cut down vertically after a thorough fermentation has taken place, mixing well with the shovel at the same time.

The other is to mix thoroughly the ingredients at first, and allow the mass to stand until used.

The effects of composts thus prepared far exceed the indications of analysis, and, cost considered, are truly remarkable.

Formulæ for Composting.—If the stable manure and cotton seed have been preserved under shelter, use the following:

FORMULA NO. 1.

Stable Manure	650 lbs.
Cotton Seed (green)	650 lbs.
Superphosphate	700 lbs.
Making a ton of	2,000 lbs.

Directions for Composting.—Spread under shelter a layer of stable manure four inches thick; on this sprinkle a portion of the phosphate; next spread a layer of cotton seed three inches thick; wet these thoroughly with water, and then apply more of the phosphate; next spread another layer of stable manure *three* inches thick, and continue to repeat these layers in the above order, and in proportion to the quantity of each used to the ton, until the material is consumed. Cover the whole mass with stable manure, or scrapings from the lot one or two inches thick. Allow the heap to stand in this condition until a thorough fermentation takes place, which will require from three to six weeks, according to circumstances, dependent upon proper degree of moisture, and the strength of the materials used. When the cotton seed are thoroughly killed, with a sharp hoe, or mattock, cut down vertically through the layers; pulverize and shovel into a heap, where the fermentation will be renewed, and the compost be still further improved. Let it lie two weeks after cutting down; it will then be ready for use.

The following plan of mixing, gives equally satisfactory results: Mix the cotton seed and the stable manure in proper proportions, moisten them with water, apply the proper proportion of phosphate, and mix thoroughly, shoveling into a mass as prepared.

There is some advantage in this plan, from the fact that the ingredients are thoroughly commingled during fermentation.

For Cotton.—Apply in the opening furrow 200 pounds, and with the planting seed 75 or 100 pounds, making in all 275 or 300 pounds per acre. If it is desired to apply a larger quantity, open furrows the desired distance, and over them sow, broadcast, 400 pounds per acre; bed the land, and then apply 100 pounds per acre with the seed.

For Corn.—Apply in the hill, by the side of the seed, one gill to the hill. An additional application around the stalk, before the first plowing, will largely increase the yield of grain.

If the compost is to be used on worn, or sandy pine lands, use the following:

FORMULA NO. 2.

Stable Manure	600 lbs.
Cotton Seed (green)	600 lbs.
Superphosphate	700 lbs.
Kainit	100 lbs.
Making a ton of	2,000 lbs.

Prepare as directed for No. 1, moistening the manure and cotton seed with a solution of the kainit instead of water. Muriate of potash is the cheapest form in which potash can be used, but kainit supplies it in a better form and combination for many plants.

If lot manure, or that which has been so exposed as to lose some of its fertilizing properties, is composted, use—

FORMULA NO. 3.

Lot Manure	600 lbs.
Cotton Seed (green)	500 lbs.
Superphosphate	700 lbs.
Sulphate of Ammonia	60 lbs.
Kainit	140 lbs.
Making a ton of	2,000 lbs.

The sulphate of ammonia and kainit must be dissolved in warm water, and a proportionate part of each sprinkled upon the other ingredients as the heap is prepared. Apply as directed under No. 1, to cotton and corn. To wheat or oats, apply 400 or 500 pounds per acre, broadcast, and plow or harrow it in with the grain.

CONCLUSION.

The knowledge of the principles, materials, and methods of application of fertilizers is of great, and in fact, fundamental importance to the farmer; especially is it so in respect to the vast variety of commercial fertilizers offered in the market. He must learn not only that different plants and different soils require different fertilizers and in different degrees and varying proportions. He must also learn that of the many elements all may have too widely different values according to the purposes to which they are to be applied, since many, perhaps all, are used in other arts.

The commercial value is that which they bear in the market. The value of the several elements vary greatly when consid, ered as the food of plants. And not only is this so, but the value, especially of the three most important of these elements varies according to the sources from which they are derived or the forms in which they present themselves. The commercial value of these several articles varies according to the course of the market. Their values as fertilizers is constant.

The table of Trade Values, on pages 23 and 24, shows what they were worth as commercial commodities in 1881. They have, for the most part, considerably declined since that time, but this table is still valid to show their relative values (approximately). From this table we observe that whilst nitrogen from nitrates were worth 26 cents per pound, nitrogen from horn, hair, &c., were worth only 11 cents. Phosphoric, soluble in water, was worth 12½ cents, whilst the same article, insoluble ine fine ground rock phosphate, was worth only four cents. Potash in high grade sulphate, was worth 7½ cents, whilst potash in muriate or potassium chloride, was worth only 4½ cents. There is another subject of even greater importance than that of fertilization, upon which there, at least, seems to prevail great ignorance among farmers, and that is the necessity of proper cultivation—or the communition of breaking up of the soil to the finest possible condition. It is a fundamental error to assert, as is sometimes done, that cultivation is fertilization, but the actual effect is substantially the same, as it not only destroys the vegetation which shares the elements with the crop, but developes the inert material of plants previously existing in the soil, absorbs the moisture and fertilizing gasses from the air, and serves to facilitate the digestion of all the existing fertilizing material from whatever sources derived to co-operate in the growth of the crop.