Agricultural Catechism;

OR,

THE CHEMISTRY OF FARMING MADE EASY.

A TEXT BOOK

FOR

THE COMMON SCHOOLS IN NORTH CAROLINA.

BY A TEACHER.

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Contents.

Preface.

This little volume has been prepared to meet a want which the author has long felt in his own school.

Very few of the young men of the country can hope, if it were desirable, to succeed in any of the so-called learned professions.—The cultivation of the soil is the business to which a very large majority of them must direct their energies.

Notwithstanding this fact, very few of our schools seem to regard the science of farming as worthy of any attention ; and probably the chief cause of this is, that we have never had a suitable text-book.

The works of Liebig, Johnston, Stockhardt, and others, are not suited to the capacity of those who are not acquainted with Chemistry ; and even to those who can comprehend them, their views seem often to conflict with the teachings of nature.

This volume is offered to the teachers of North Carolina in the hope that they will find it of some value in arousing a spirit of inquiry among their pupils, in regard to the long neglected subject of which it treats. If it contains errors, the author will be no less pleased than they will, in having them exposed. His experience in practical farming is very limited, as the reader cannot fail to discover, and he has never conversed with a practical farmer who, at first, agreed with him ; but after a full discussion of his views, their correctness has seldom been denied, and it is this fact which has encouraged him to present them to the public.

B. F. GRADY, Jr.

NEUSE RIVER ACADEMY,
Wayne County, N. C., June, 1867.

Agricultural Catechism.

LESSON FIRST.

Three Kingdoms of Nature.

QUESTION. The earth and its inhabitants are divided into three classes or kingdoms. Can you tell me what they are?

ANSWER. Those objects which do not possess life, as the land, the water and the atmosphere, are classed as the MINERAL KINGDOM; those which possess life, without the power of locomotion—the trees and the plants—are classed as the VEGETABLE KINGDOM; and those which are endowed with both life and locomotion, are called the ANIMAL KINGDOM.

Q, What supports the growth of the Vegetable Kingdom?

A. Elements or food furnished by the Mineral Kingdom.

Q. What supports the growth of the Animal Kingdom?

A. The Animal Kingdom lives on both the others. The Mineral Kingdom supplies it with water and air, and the Vegetable Kingdom supplies it with the elements of its flesh, bones, hair, &c.

Q. Do not plants derive nourishment from the Animal Kingdom?

A. Yes; when an animal dies, its body undergoes a change, and is re-converted into its mineral constituents, and then serves as food for plants. The case is the same when a plant dies.

Q. All plants and animals were once earth, air, and water, then?

A. Yes; and will become so again.

Q. If that be so, some of the substances which compose my body may have been derived from the moss of Lapland, or the huge serpents of South America. Is that the belief of philosophers?

A. Yes; nothing is lost or destroyed. When wood or flesh rots, it undergoes nearly the same changes as when consumed by fire. It is converted principally into vapors and gases, which are carried by the winds to distant parts of the earth. Thus your body, when decayed, may furnish food for the tea plants of China, or the vineyards of France.

LESSON SECOND.

Structure and Composition of the Earth's Crust.

Q. In order to arrive at a proper understanding of the mode in which, and the sources from which, vegetables obtain their food, we must have a correct knowledge of the constitution and structure of the earth's surface, and of the constitution of the atmosphere. We will begin with the earth. Can you tell me its condition as far down as the roots of trees reach?

A. Mines, railroad cuts, wells and hillsides show that the earth's crust is composed of layers, or strata, of various substances and various thicknesses. The top stratum is generally sand or clay; the next one is clay, sand, pebbles, sandstone, ironstone, limestone, or some other rock. In some places we see several thin layers; in others not more than one or two thick ones are exposed.

Q. Do these strata occupy a horizontal position.

A. No; they are neither horizontal nor continuous. Their continuity is very much broken by water courses, the streams having cut their channels, in some places, through several strata. In some instances they are horizontal throughout a considerable district.

Q. What do we find in these strata, besides the substances you mentioned?

A. Salts of potash, soda, lime, magnesia, &c., water, and compounds containing sulphur, phosphorus and other substances which plants and animals require.

Q. What is potash?

A. It is the substance which we extract from the ashes of certain trees for the manufacture of soft soap. When purified, it is sold in the shops as "concentrated lye," pearl ash, saleratus, &c.

Q. What is soda?

A. A substance resembling potash. It is extracted from sea-salt, or the ashes of sea weeds, and is used in the manufacture of hard soap, and as a substitute for yeast in making light bread.

Q. What is magnesia?

A. It is a white powder, also resembling potash, and is extracted from certain rocks. It is used as a medicine.

Q. Are these substances necessary elements in the structure of plants?

A. Yes; there is no vegetable which does not yield an appreciable quantity of ashes when consumed. These ashes are potash, soda, lime or magnesia, and generally more or less of each.*

Q. There is some mystery about this. There are fields which have produced crops for more than a hundred years without ever having had any manure, ashes or lime put on them, and the crops are as good to-day as they were fifty years ago; notwithstanding this, no one of these salts appears in the soil, in any sensible quantity. Moreover, if I should remove all the dirt from around the roots of a black-jack and lixiviate it, I should scarcely be able to detect any potash in it. How do you explain this?

A. The several strata composing the earth's crust, as said before, contain all the salts needed by plants, and we can readily understand, therefore, that the supply is inexhaustible, and we shall only have to explain how they are brought within reach of the roots.

Q. You mean, then, that the salts are brought to the roots, instead of the roots going after the salts?

A. Yes; the evaporation of moisture from the earth's surface causes a continual flow of water upwards from the depths of the earth, which brings up the potash, soda, &c., in solution. You know that they are soluble in water.

* Ashes contain other substances which will be mentioned in due time.

Q. Lime is not soluble in water, is it?

A. Yes; oysters, clams, &c., in the oceans, and muscles, in the rivers and creeks, construct their shells out of the lime which they find in the water.

Q. Whence do rivers and creeks obtain their lime?

A. In some countries there are immense beds of marble, chalk and limestone, and where these are wanting, we generally find beds of marl. All these are salts of lime, and are gradually dissolved by the rains and washed into the streams.

LESSON THIRD.

How Plants are supplied with Moisture, Potash, &c.

Q. Can you now tell me what becomes of the water that falls on the earth?

A. One portion, if there be much of it, runs into the creeks directly; the rest soaks into the ground and descends to an impervious stratum; here it stops, occupying the level of the wells in the neighborhood.

Q. What is an impervious stratum?

A. A layer of clay, or some rock through which water does not penetrate, or very sparingly, if at all.

Q. What becomes of it then?

A. If that impervious stratum slopes in any direction, the water follows the slope, until it comes to the boundary or edge of the stratum. If it terminates on a hillside, the escape of water is often so abundant that the earth there is very damp, and sometimes the water issues in streams constituting springs.

Q. That reminds me of a strange phenomenon I have often witnessed: I recollect a small branch which crosses a road, and I have often observed that although running briskly in the morning, it would be dry in the evening. Can you explain it?

A. When the atmosphere is dry and the sun is shining, the water which issues from the hillsides to supply that stream is evaporated ; but if the atmosphere is damp it is unable to absorb the water as it comes out, and consequently it accumulates in a sufficient abundance to form a current. Night would also favor this.

Q. Why is this occurrence a sign of rain ?

A. Because, when we see water running in such places we know that the atmosphere must be very damp, and consequently a rain is reasonably expected.

Q. Well, a sharp-eyed farmer ought to be able to be his own weather table. But you mentioned an upward current of water ?

A. Yes ; besides the lateral escape just described, there is always an upward flow to supply the loss created by surface evaporation. As soon after a rain as the sun and atmosphere have dried the surface of the earth, capillary attraction brings up more water to moisten it.—This is, in turn, evaporated, and leaves room for more from below. This current, you recollect, fetches up the potash, &c., to the roots of plants.

Q. As our crops do not extract from the water all the salts it has in solution, there must be an accumulation of them in the soil, after two or three weeks dry weather. What do you think is the consequence ?

A. The pores of the soil become choked, and prevent the further escape of moisture. The ascent of these salts is, of course, stopped, and the crop languishes.

Q. How can this be remedied ?

A. By stirring the land or breaking its crust.

Q. Why does a heavy rain injure a crop ?

A. Chiefly by patting the soil down, and thus lessening its porosity ; but it is not unlikely that an excess of water dissolves and carries down, out of the reach of the roots, all the soluble substances in its passage. In this case the injury must be considerable.

LESSON FOURTH.

Rotation of Crops, &c.

Q. Why does it damage land to plant one sort of vegetable on it every year ?

A. Every species of plants requires a certain proportion of each of the inorganic elements (salts) in the soil to insure its vigor. As every plant extracts from the earth more of one salt than of the others, of course a repetition of the same for a number of years destroys the due proportion.

Q. How would you remedy this ?

A. I would restore the deficient salt to the soil, or plant some crop which would remove the other salts in larger proportion.

Q. You do not understand, then, that land is exhausted when it fails to produce the same crop repeatedly for a number of years?

A. By no means.

Q. Do you think there is any difference in lands, in this respect?

A. Yes; if the impervious stratum or water bed be several feet below the surface, there is so much room for diffusion, that years may elapse before any salt can become injuriously deficient. There are many fields in Eastern Carolina which have produced crops of corn and peas together for scores of years, and supply potash, lime, &c., now as abundantly as ever.

Q. May not these two plants counterbalance the action of each other, so as not to disturb the proper proportion of the salts ?

A. Perhaps they do. Analysis shows that corn removes from the earth much more of potash and soda than of lime and magnesia; while peas exactly reverse the case, removing much more of lime and magnesia.

Q. Planting these together, then, is about the same as a rotation of crops ?

A. Yes; and here we have a striking proof of the goodness of God. Corn and peas are both valuable articles of food for man and beast, and planted together they scarcely make any impression on the mineral constituents of soils.

Q. What is the case if the water-bed be near the surface?

A. Of course, one year's growth of peas, for example, may remove enough of lime and magnesia to destroy the due proportion.

Q. How could that be remedied?

A. In no other manner than by restoring to the soil the salt or salts which it needs.

Q. Does the earth furnish anything else to our crops besides what you have mentioned?

A. Yes; iron rust and sand are found in the ashes of almost all plants, and the rust of manganese in those of a few. Sand is dissolved in the soil by potash or soda, and carried up and deposited in the bark and leaves, for the purpose of strengthening them. The sharp edges of grass leaves depend for their firmness on the sand they contain.

Chlorine, sulphur and phosphorus are, also, found in the ashes of all cultivated plants.

Q. What is chlorine?

A. It is a greenish gas found in common salt, and in some other compounds. Common salt is composed of this gas and a metal called sodium. Calomel is the same gas and quicksilver combined.

Q. In what condition does sulphur exist in the earth?

A. Generally combined with oxygen gas and lime, in gypsum, or with the same gas and iron, in copperas. Phosphorus is generally found in a similar condition. It unites with oxygen and lime or magnesia, in phosphate of lime or phosphate of magnesia.

LESSON FIFTH.

Constitution of the Atmosphere, and of Organic Matter.

Q. Well, you have pointed out the sources from which plants obtain their mineral or earthy elements. We will now examine the constitution of the atmosphere. Can you tell what it is composed of ?

A. Oxygen and nitrogen gases are its chief constituents.

Q. Tell me what oxygen gas is ?

A. It is the vivifying element of every breath we draw; without it, all animals would perish. It is the substance which unites with the fuel in our fireplaces and stoves, and carries it off in a gaseous condition; without it, all our fires would go out. It is the substance, moreover, which unites with iron and other metals, producing rusts or oxides, and with lifeless animals and vegetables, causing them to rot and pass away in a gaseous form.

Q. What is nitrogen ?

A. Its chief office, probably, is to dilute the oxygen, just as water is used to weaken intoxicating liquors.—The action of pure oxygen is too energetic. Wood and other combustibles, when set on fire and plunged into a vessel of oxygen, burn up with astonishing rapidity, and living animals very soon die in it.

Q. What else is there in the atmosphere ?

A. Of course it contains all the gases produced by the combustion and decay of wood, &c., as well as all those which are generated by the putrefaction of animals, manures, &c. The odors of flowers, too, must be included.

Q. What are the substances in plants and animals which, in decay and combustion, combine with oxygen and pass off as gases ?

A. To answer this we must know something of their constitution. You are aware that a large per cent. of animal and vegetable matter is water. Well, if we cover up in hot ashes a piece of flesh, some blood, some grains of corn, or a portion of any other organized matter, and let it remain so for a considerable time, all the water will be driven off, and there will be left a black mass which we call charcoal. If, now, we set fire to this charcoal and let it burn up, there will be left a small quantity of ashes.* That which is consumed is what chemists call carbon. It unites with oxygen and produces carbonic acid gas.

Q. That is remarkable. How do you account for the color of wood if it consists of nothing but ashes, water and carbon ?

A. That is probably inexplicable. Sugar, cotton, starch and rice have the same constitution.

Q. That makes the combustion of such substances a simple process. The oxygen combines with the carbon only, producing carbonic acid gas. Does carbon ever appear in the pure state ?

A. Yes; the diamond is pure carbon, and black-lead or plumbago is nearly pure carbon.

Q. How can there be such a difference in the character of compounds having the same elements ?

A. A difference in the proportion causes it. There are several compounds, however, which have the *same elements* in the *same proportion*. Nine pounds of starch, for example, are composed of five pounds of water and four pounds of carbon; and the constitution of cane sugar is exactly the same.

This fact enables us to understand why a yam potato becomes sweeter after its removal from the earth. Its starch is gradually converted into sugar. Slow baking produces the same result.

It also enables us to understand why a grain of corn grows sweeter at the time of sprouting. Its starch is insoluble, and cannot serve as food for the little plant; but God has wisely provided that it shall be converted into sugar, so as to become soluble! The same is true of all cereals.

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*This simple analysis must not be considered exhaustive ; heat drives off other substances besides water.

LESSON SIXTH.

How Plants Grow.

Q. If organized substances were to continue to decay, they would, after a while, use up, or combine with, all the oxygen of the atmosphere, thus producing carbonic acid. Could we live in it?

A. No; we must have oxygen. But you should be able to solve your own difficulty. The growing plants are continually employing carbon to build up their own bodies. *The carbonic acid is their food;* they absorb it through the pores in their leaves, separate the oxygen from the carbon, and the sap carries it where it is needed. The oxygen comes back into the atmosphere for us to breathe. Thus, you see, how beautifully, as well as wisely, the beneficent Creator has provided for the sustenance and comfort of His creatures.

Q. I thought the food of plants was taken in by the roots.—What proof have you that your account is correct?

A. There are some vines which will continue to grow after they have been cut off from their roots; I saw once a cactus, or prickly pear, growing vigorously on top of a stone wall, three feet high, where it had been placed four or five years before; a poor field, if properly managed, will become more and more fertile, without any artificial application of manure. This, of course, is impossible, if the earth furnishes the nourishment. Fence rows are remarkable instances of this fact. They become very fertile after a few years, although the land may have been quite barren at the time the fence was laid.

Q. But may not the carbonic acid be absorbed by the moisture of the soil, or be carried down by rains, and thus come within reach of the roots?

A. I believe rain-water is not found to contain this gas in any appreciable quantity. Indeed, water does not appear to possess much affinity for it. If it did, a copious shower of rain would leave very little of it in the atmosphere. But the fact is, no amount of rain has ever caused any sensible diminution of carbonic acid in the atmosphere. Moreover, we find little or none of it in the various bodies of water on the earth, which fact disproves the existence of any affinity between them. It is true some springs are impregnated with this gas, but a little exposure to the atmosphere soon rids them of it. Thus it is not likely that *any* water carries carbonic acid to the roots of plants.

Q. Your reasoning seems conclusive against the admission of large amounts of this gas by the roots of plants. Can you mention any fact that denies the admission of any at all?

A. You recollect that there is a constant flow of water from the great reservoir under us, up to the surface, to supply the loss by evaporation, and to bring up the potash, &c., to the roots of the crops. It seems a physical impossibility that this water can carry any carbonic acid into the roots, because it has none to carry. This is *beyond question*, when the roots reach below the organic matter in the soil, as in the case of trees.

LESSON SEVENTH.

Nitrogen in Plants, and whence they obtain it.

Q. Are there no other elements in plants besides those you have mentioned?

A. Yes; the nitrogen of the atmosphere is found in some parts of plants. If you place some flour dough on a piece of cotton cloth stretched over the mouth of a jar and pour water to it, you will after awhile, by continually stirring and washing it, separate it into two parts. One part will be starch and the other gluten. The starch, as I told you, is composed of water and carbon. The gluten, which is a viscid substance, contains nitrogen.

Q. Is there any general difference between those compounds containing nitrogen and the others?

A. The former undergo decay more readily, and produce gases much more offensive. This explains the difference between lean meat or muscle and fat meat.

Q. Does animal matter contain nitrogen too ?

A. Yes ; and in a much larger proportion than vegetable matter.

Q. Well, now tell me how plants obtain their nitrogen. Do their leaves drink it in from the atmosphere, as in the case of carbonic acid ?

A. This question is in considerable doubt, those who seem competent to consider it, differing widely in their opinions. In order to enable you to understand what is known about it, I will inform you that nitrogen occurs, in the earth and atmosphere, in two compounds, nitric acid and ammonia. Nitric acid is a compound of nitrogen and oxygen, commonly called aquafortis. It is generally found combined with potash, forming saltpeter.—In this state, of course, it can be absorbed by the roots of plants. Whether this is the fact, we will inquire after we describe ammonia.

Ammonia is composed of nitrogen and hydrogen, (the gas which unites with oxygen to produce water,) and is commonly called *hartshorn.* It is a natural product in the decay of all animal matter. You can smell it quite distinctly in horse stables, when the weather is warm.

Q. If it is a gas, may it not enter into plants through their leaves ?

A. The general impression is that rain washes it into the earth where it comes in contact with the roots, but this is very doubtful.

Q. If the rotting of manures produces ammonia, cannot the roots absorb it as fast as liberated ?

A. Yes; but many crops grow where there is no manure—at least, animal manure—and, nevertheless, obtain their due share of nitrogen. Besides, repeated experiments have satisfied the leading Agricultural Chemists that certain crops have removed from the field twice as much nitrogen as was supplied in the manure. Evidently some, if not all, of it came from the atmosphere. Johnston's Agricultural Chemistry mentions a fact which leads to the belief that the atmosphere supplies ammonia directly to the leaves of plants. Sprengel states "that it has very frequently been observed in Holstein that if, on an extent of level ground sown with wheat, some fields be marled, and others left unmarled, the wheat on the latter portions will grow *less luxuriantly*, and will *yield a poorer crop than if the whole had been unmarled.*"

Q. How? I do not understand you.

A. It is impossible for the marled fields to lessen the amount of the nitrates, (saltpeter, &c.,) or of the salts of ammonia in the soil of the unmarled fields; but they *can diminish* the available nitrogen in the atmosphere.

Q. How so?

A. The atmosphere sometimes stands nearly still over large districts of country for several hours, and even days. Under such circumstances the healthy and vigorous individuals of the vegetable kingdom appropriate much more than an average share of whatever food they find in it, and of course their less thrifty neghbors suffer. I will mention another fact which confirms this view: There is no nitrogen in mud, although it is one of our most valuable fertilizers, and often causes a crop of corn to be twice as rich in nitrogen as it would be otherwise. We will probably recur to this question after we inquire into the philosophy of manuring.

LESSON EIGHTH.

Use of Manures.

Q. Well, really, I do not see the use of manures, if your acconnt of the growth of plants is correct, unless it be to supply the atmosphere with carbonic acid gas and ammonia, and for this purpose they might as well be in the stables as in the fields. What purpose do they serve?

A. Besides what you have mentioned, they *keep the ground warm.*

Q. Is that all we gain by hauling manure into our fields ?

A. Very nearly. It is well known that plants grow more vigorously in warm than in cold climates. They require an *elevated temperature which shall be constant.*—In our latitude the sun heats the earth during the day, and radiation cools it during the night. To remedy this evil we incorporate with our soils a considerable portion of organic matter which, in rotting, generates a uniformly elevated temperature.

Q. Why does the rotting of manure create heat ?

A. I have already told you that the combustion of organic matter and the decay of it are, with scarcely an exception, identical processes. The oxygen of the atmosphere combines with its elements, producing heat in both cases.

Q. That is the cause, then, why heaps of manure become so hot sometimes. I have often observed that when pulling up potato sprouts the manure in the *slip-bed* was very warm.

A. Yes ; and you had then a striking exemplification of the office of the manure. It makes the potatoes or slips sprout very rapidly, but gives no nourishment to the young plants, *because they have no roots to receive it.*—Moreover, we know that, in favorable weather, potatoes sprout even when lying on a dry plank floor.

Q. Why are we so careful to rid our cornfields of grass ? Is it not because the grass extracts from the earth the nourishment we intend for the corn ?

A. Grass shades the land by day, and becomes so cool, by radiation at night, that it reduces the temperature of everything near it. In *this* way it injures land. If your supposition were correct, one year's growth of corn and grass together ought to exhaust the soil completely, which is far from the truth.

The experience of farmers confirms this explanation. At the time when the ears begin to form on corn, and when, of course, it demands its most valuable nourishment, *grass is allowed to grow.* The reason is that the summer is so far advanced, and the earth has become warm to such a depth, that the radiation and shading of grass cannot injuriously lower the temperature of the soil.

Q. Well, that is remarkable, I have always had a very different opinion. Do you really suppose that manure supplies no food to the crop growing on it?

A. The rotting of organic matter, as said before, produces carbonic acid and ammonia. These are both gases, and rise up into the atmosphere as fast as generated. They do not go downwards. If, therefore, the manure be spread on a field, the crop growing there will be continually enveloped in an atmosphere fully impregnated with these gases; and, consequently, the plants will be able to absorb, through their leaves, an abundance of food.

LESSON NINTH.

Lime, Marl and Ashes. Animal and Vegetable Manures; the difference between them. Bones, &c.

Q. Why do persons put lime and ashes on their fields?

A. Because they hasten the rotting of the organic matter in the soil, and thus increase its temperature.—This will enable you to understand why many farmers have become opposed to the use of lime, declaring that it injures land. It is because they have used it on fields which contained very little organic matter; in which cases, of course, the organic matter very soon decayed, and left the crops *in the cold*, at the most important period of their growth.

Q. Does not lime serve as food to the plants?

A. It is true, plants extract a small quantity of lime from the soil, but on most lands they find as much as they need, without an artificial supply.

Q. A farmer, then, should not put lime or ashes on his land, unless it is already well charged with organic matter?

A. No. The advantage of putting them on such land is shown by the effect of the ashes produced by the burning of log and brush-heaps in our rich low-grounds.

Q. How do these substances hasten the decay of organic matter?

A. In the present state of our knowledge that question is probably unanswerable. We simply know the fact.

Q. Why is animal manure more active than vegetable manure?

A. Animal manure, such as we get from stables, hog-pens, &c., is more energetic than mud, turf, leaves, straw, &c.; because it *rots faster* and generates *more heat.* You recollect that compounds containing nitrogen decay more rapidly than those which are destitute of it.

Q. Did you not state that nitrogen is found in plants as well as in animals?

A. Yes; but only in certain parts of plants. In the ordinary vegetation of our country nitrogen does not occur, except in the seeds.

Q. I see now the reason why it is bad policy to mix lime or ashes with horse-stable manure: it is because it soon destroys the animal matter out of it;—is it not?

A. Yes; in that, as well as in cow, hog, sheep, goat and hen manures, there is a large per cent. of nitrogen compounds which, by their own readiness to-day, hasten the rotting of the whole mass.

Q. How do you explain that?

A. Probably by the abundance of heat which they impart to it; but this is not certain. We may be unable to give the true cause. I have little doubt that electricity exerts a considerable influence in the case.

Q. How do you account for the action of marl? I have heard of numerous cases where marl applied to poor land enriched it very much. Is there anything in it to rot and generate heat?

A. Yes; marl consists of the shells and remains of innumerable animalcules. These insects have been locked up from the atmosphere for thousands of years, probably, and could not rot, therefore. When the marl is spread on a field and mixed with the soil it loses its tenacity, and becomes sufficiently porous to allow the oxygen of the atmosphere to come into contact with the animalcules. You see, then, that marl *can generate heat.*

Q. Is not lime sometimes applied to marshy, "sour" places with good results ?

A. In such places a large amount of vegetable acids have been produced, which are injurious to vegetation.— Lime combines with or destroys them, i. e., makes them decay.

Q. What effect have bones, superphosphate of lime, guano, &c., on land.

A. Bones consist of animal matter—jelly, oil, &c.— and phosphate of lime. Guano is composed of animal matter, phosphate of lime, salts of potash and soda, and plaster of Paris. The action of the organic matter and the potash and soda needs no further explanation.— Phosphate of lime, plaster of Paris, and the inorganic portion of marl, exert a stimulating influence; but probably one effect of their application to land is simply to diminish its *radiating power*, so as to prevent it from cooling rapidly at night. Some of the phosphate may enter into the plants.

Q. A plant does not require anything, then, but earth, air, heat and water ?

A. Yes; the sun's rays have a powerful influence on the vegetation of the earth, and as I intimated, probably electricity is no less powerful. Plants cannot thrive in the dark.

LESSON TENTH.

More about Nitrogen.

Q. You promised to say more about nitrogen after you examined the philosophy of manuring. In Johnston's Agricultural Chemistry* there is an account of an experiment made with nitrate of soda, (soda-saltpeter,) in which it is shown that a wheat-field was very much benefited by a top-dressing of this salt. Is it not likely that some of this nitrogen served as nourishment for the wheat ?

* Edition of 1842.

A. No; this appears in a list of experiments, in which it is also shown that common salt, similarly applied, produced a greater yield of wheat than the nitrate of soda did; and you recollect that common salt is composed of chlorine and sodium. The difference of yield was *three hundred and twenty* pounds of grain per acre *in favor of the salt.*

Q. Yes; but this wheat weighed only sixty-two pounds to the bushel, while the other weighed sixty-three.

A. That is true; but there is a still more remarkable fact exhibited in the same table: A mixture of salt and lime produced wheat which weighed *sixty-three and a half pounds* per bushel. On the whole, therefore, I suppose the nitrates affect vegetation just as lime does, by hastening the decay of organic matter, and lessening the radiating power of the soil.

Q. Does not nitrate of soda, when put on grass land, or on fields of wheat, &c., as a top-dressing, cause the leaves to assume a dark green color?

A. Yes; but even then the yield of hay or grain is less sometimes than on similar land where no nitrate is applied.

Q. How do you explain the color?

A. I suppose the nitrate stimulates the vital principle of the plant to unusual activity in the preparation of coloring matter, just as intoxicating liquors arouse some men's combative dispositions.

LESSON ELEVENTH.

Sawdust, &c. Flow of Sap. Mode of Manuring. Depth of Plowing, &c.

Q. What is the action of pine straw and sawdust spread over an Irish potato patch?

A. These substances prevent the sun from drying the soil and producing a hard crust on its surface. They also prevent heavy rains from packing the soil, and preserve a uniform temperature.

Q. Does sap rise in the Spring and descend in the Fall?

A. No; there is a *continual circulation* of sap, analogous to that of the blood. It ascends through the center or heart of a tree, and descends through the outer parts near the bark. In its ascent, it carries the elements of its ashes, obtained from the earth; in its descent, it carries the carbonic acid and ammonia, furnished through the leaves. The case is the same with corn, wheat, &c.

Q. Why is the bark of most trees loose in the Spring?

A. Because such trees add to their size one layer per year. This layer is commenced in the spring, and is at first nothing but a liquid. Being, of course, between the bark and the solid wood, the former can be easily peeled off.

Q. Why will a green water-melon ripen rapidly, if we cover it up with earth?

A. Because the rind performs the same office that leaves do. It extracts from the atmosphere the required nourishment. When buried, therefore, this action ceases and the vital power of the melon directs its energies to the maturing of the materials on hand—ripens it.

Q. How deep should we put manure?

A. If we place it on top of the ground, it will soon become dry, (stable manure,) in which case it cannot readily decay; and if it should, its heat cannot descend far into the earth. Consequently the corn roots will stay near the surface where it is warm, and if there be much dry weather they will suffer for water.

Q. Why cannot the heat descend?

A. Because the earth is a bad conductor, and the upward current of water has a tendency to make the surface as cool as itself. This is proved by the limited depth to which the heat of very large fires warm the ground.

If we place the manure very deep in the earth, so that the atmosphere cannot come into contact with it, it cannot rot, and will be useless. The depth at which it should be put depends on your mode of plowing.

Q. Why so?

A. All the manure below the furrow which your plow makes, and which is left undisturbed, does little or no good, because the oxygen cannot penetrate it and cause it to decay.

Q. Do you think we should stick the plow in as far down as the manure extends every time we plow?

A. No; one such plowing every Spring, just before planting, is sufficient. To obtain the best results, I should thoroughly incorporate my soil with manure to the depth of fifteen inches, at least. To do this, I should spread on say one hundred ox-loads to the acre and plow it in, and should repeat the operation as often as possible. After the soil should become as fertile as I could make it, I should lessen the dose of manure, but not the depth of the plowing.

Q. Would it not do to apply a sufficient amount at once?

A. Not so well, if it were farm-yard manure. It would be difficult to mix it thoroughly with the soil, and the heat generated by it would not be uniformly distributed. Besides, I should be afraid there would be too much heat, and my crop would get "fired," as the farmers term it.

Q. Suppose you had mud or turf?

A. In that case it would be better to plow in a full supply at once.

Q. If, in the Spring, you should cover up an ordinary coat of manure with fifteen inches of earth, you would render the land useless. The surface would be barren sand or clay, and the atmosphere would never reach the manure.

A. That is very true. I would not treat my whole farm in that way at once, unless I could repeat the operation before planting, and very few farmers can find time and manure to do this. It would be better to take a small piece of ground at a time. I could do this whenever I should have the manure ready and time to spare.

It would not require many years to prepare, in this way, as many acres as I should need.

Q. If you used mud would it not be necessary to add a little lime every Spring?

A. Yes; unless I had farm-yard manure enough.—You recollect that I told you that animal matter rots much faster than vegetable matter, and when mingled with mud it would serve the same purpose as lime.

LESSON TWELFTH.

Fermentation. Compost Heaps. Lamp-black, &c.

Q. Why do farmers wait for compost heaps to ferment before using them?

A. Because fermentation is a rapid decay which disintegrates or pulverizes the solid matter of the heap.

Q. What causes this rapid decay?

A. It is caused by the rotting of the nitrogenized substances—generally animal matter.

Q. Does all the animal matter rot, then?

A. That depends on the length of time the process is allowed to go on. If it continues 'till the heap begins to cool, it is quite certain that the nitrogenized compounds all decay.

Q. The ammonia is all gone then, is it not?

A. Certainly; and the heap is pure vegetable matter.

Q. What is the advantage of having the solid substances pulverized?

A. They can be uniformly disseminated through the soil, and can decay more easily.

Q. How can they decay more easily?

A. More surface will be exposed to the action of oxygen; just as a pound of clean iron-filings can become rust much sooner than a pound of the same metal in one piece.

Q. You have conveyed the idea all along, that no substances, simple or compound, found in our ordinary manures, can produce as much heat as those compounds containing nitrogen. Is that so?

A. No. Heaps of oily rags or cotton sometimes absorb oxygen and become so hot as to blaze. The same is true of mixtures of linseed oil and lamp-black, if the proportion of oil is small or the mass is dry.

Q. What is lamp-black?

A. When wood is burning in our fireplaces, a small quantity of the carbon rises in a gaseous state, and meets no oxygen until it has become too cold to unite with it. Consequently it passes away in the smoke or lodges on the walls of the chimney. This is lamp-black.

Q. Could these substances be made available as manures?

A. Lamp-black and pounded charcoal have been used to great advantage on grass lands. Experiments mentioned by Johnston show that while salt caused an increase of one ton per acre in the hay grown on a certain farm, *soot* caused an increase of eighteen hundred weight, and nitrate of soda caused an increase of twelve-hundred weight. They were used as top-dressings, May 24. Thus you see *soot* is a better fertilizer than the *nitrate of soda.*

Q. Do you think the advantage resulted from the decay of the soot, or from its covering the soil and preventing the escape of heat?

A. Probably from both.

Q. What causes cotton seed to ferment when composted with leaves, turf, &c.?

A. The analysis of cotton seed shows that nearly one-fourth of their substance consists of nitrogen compounds. They contain, also, nearly ten per cent. of oil. It is most likely, therefore, that their fermentation is the result of the conjoint operation of both the causes mentioned before.

Q. Is it better to make compost heaps with cotton seed, or spread and plow them into the soil?

A. That depends on the condition of the soil. A much larger amount of manure can be prepared by making the heaps, and I think the seed can be rendered more serviceable in this way. If, however, a field were well supplied already with vegetable matter, especially mud, it would be better to plow them into it.

Q. Are there other seeds which could be used in a similar manner ?

A. Yes ; if we had enough of them.

LESSON THIRTEENTH.

Sand, Clay, &c. More about Compost Heaps. Top-Dressing.

Q. Why does sand put on stiff mud land improve it ?

A. The soil is rendered porous, so that the water below can escape through it, and the oxygen can readily penetrate it. Moreover, corn grown on mud has weak stalks and is easily blown down. You recollect I told you that the strength of the stems and leaves of corn, grass, &c., depends on the sand in their composition.

Q. Does not the addition of clay often benefit sandy soils ?

A. Yes; sandy land is too porous, generally. It allows too much evaporation of moisture, which tends to cool it; and oxygen can penetrate it so freely that no organic matter can remain in it long. It soon rots out. The application of clay remedies these evils; and the same may be said of any other tenacious substances, as marl, plaster, &c.

Q. Might not sand benefit stiff clay land on the reverse principle ?

A. Undoubtedly. If such lands, however, were well charged with organic matter, that would render it light and porous.

Q. What other substances are found on our farms which could be made available as fertilizers, besides those you have already spoken of ?

A. One of the most valuable of all manures is night-soil.; because, containing a very great amount of nitrogenous matter; it can be used in compost heaps when the vegetable matter is largely in excess of the usual proportion. The carcasses of dead animals, the blood of butcher pens, spoiled fish, &c., &c., are equally valuable.

Q. How would you apply these substances?

A. I should first compost them with leaves, straw, cornstalks, and any other convenient vegetable matter, under a shed, which could keep off both sunshine and rain.

Q. Why exclude them?

A. Because the sun would drive out the moisture without which nothing can rot; and the rain would dissolve and wash down many substances essential to the fermentation.

Q. In making these heaps what sort of vegetable matter would you use?

A. Leaves, straw, cornstalks, &c.

Q. Would you not employ mud?

A. No; the object of such heaps is to pulverize organic matter, and mud is already pulverized.

Q. Why is it so cold, then?

A. Because the amount of water in it is so great that oxygen cannot penetrate it, and even if it could, the cooling effect of excessive evaporation would prevent any great elevation of temperature. Spread on a field and intimately mixed with the soil, it ceases to be cold.

Q. What is mud?

A. It is little else than charcoal. In some countries it serves for fuel.

Q. When would you haul out and plow in the compost heaps?

A. Just before planting corn, and, if possible, I should endeavor to arrange for the fermentation to be still progressing.

Q. Why so?

A. Because the heat generated in the soil would hasten the germination of the corn, and give the young plants a good start by the time the summer heat could relieve that of the fermentation.

Q. Did you not say the sun's heat is not sufficiently uniform for the purposes of vegetation?

A. For cultivated plants, I meant; but, of course, the earth grows warmer as Spring advances.

Q. You make a distinction between the *heat of fermentation* and that caused by the *rotting of pure vegetable matter*, as leaves and straw?

A. Yes; the latter is more uniform.

Q. Would such manure improve wheat land?

A. My impression is that it would not. If put on just before planting, the *heat of fermentation* would cause a rapid germination of the seeds; but all the nitrogenous compounds would be exhausted before Spring; thus the transition from a very warm to a comparatively cold soil would, no doubt, injure wheat.

Q. Does the experience of farmers accord with this view?

A. I am not informed.

Q. Suppose the fermentation were completed, might not an application of such manure be beneficial?

A. Of course. In that case the decay of the organic matter would be uniform.

Q. Could we not hasten that decay early in Spring by top-dressings?

A. Yes; a coat of plaster, common salt, marl, leached ashes, soot or pulverized charcoal would answer this purpose.

Q. Why not lime or unleached ashes? You said they were very powerful in hastening the decay of organic matter.

A. True; but you must remember the young wheat is organic matter. Besides, too sudden an elevation of temperature would do more harm than good.

Q. Which of the substances enumerated do you think the best?

A. No one of them would be best for all lands. So far as experiments show, common salt appears to be the best on heavy loam. I should prefer something less soluble, as marl or plaster, on sandy land. It is to be regretted, however, that our people have never adopted any general system of experimenting, and we are sadly in the dark in regard to this important question.

Q. Ought not every farmer to make his own experiments?

A. It would, no doubt, be better. An acre of ground well supplied with organic matter, could be sown in wheat at the proper time, and early in the Spring, say from the 1st to the 15th of April, it could be divided into lots according to the number of stimulants intended to be applied.

Q. How much salt would you put on an acre?

A. Experiment could give the best answer. The lot intended for salt could be subdivided into several parcels and a different quantity of salt applied to each. In this way a farmer could gain most important knowledge, in one year, at a very trifling cost.

Q. Is there no animal substance that could be employed as a top-dressing?

A. Yes; dried blood, the dried manure from poultry yards, &c., &c., would be valuable; but they would have to be in powder, and there would be danger of applying too much. They should be used with caution.

Q. Might not guano serve a good purpose as a top-dressing?

A. Undoubtedly; and so might lime, if it were mixed with some substance which would prevent it from coming in direct contact with the tender parts of the young plants.

Q. Why is horse-stable manure better than cow-pen manure?

A. Because the former contains a much larger per cent. of nitrogenous compounds, and consequently generates more heat.

Q. Why is cow-pen manure better for turnips?

A. Because turnips do not require a very warm soil; and there may be other reasons.

LESSON FOURTEENTH.

Green Manures. Commercial Fertilizers, &c.

Q. Are not green crops sometimes plowed in as manure ?

A. Yes ; for small grain particularly. Peas are probably the most valuable crop among us for this purpose ; although I am inclined to the opinion that crab-grass, in districts where it thrives, can be made to serve as good a purpose, at less cost.

Q. How could you get seed enough ?

A. I should need none. The earth preserves an abundance of seed, as is proved by the trouble farmers have in ridding their crops of this grass.

Q. What would be necessary for you to do ?

A. Simply to give the land intended for wheat a thorough plowing in the Spring, so as to insure a good coat of grass during the Summer.

Q. Why will not these green crops do as well if allowed to ripen and become dry ?

A. They will not decay so readily.

Q. How deep would you cover a green crop ?

A. Not very deep. I should be governed by the depth to which the roots of wheat extend.

Q. Can this mode of manuring be adopted with advantage for corn ?

A. That would depend on the accessibility of mud. A pea crop might cost more than an equal amount of organic matter supplied in mud.

Q. Do not peas contain nitrogenous substances ?

A. Yes ; but these would complete their fermentation before they could be serviceable to corn.

Q. Would you advise the use of commercial fertilizers ?

A. There are few crops grown on our farms which are not also consumed on them. The potash, lime, magnesia, soda, phosphorus and sulphur removed from the soil are, therefore, not carried off, and can be readily restored to the fields whence they were extracted. Cotton, it is true, when grown for market, carries off a small per cent. of these substances,—nearly one pound in a hundred; but this loss, on the farms in Eastern Carolina, where the land is light, would not be felt in a century, or probably in thousands of years. It must not be forgotten, too, that the soap, salt, lime, copperas, &c., brought on our farms, return to them many of the inorganic elements of which crops deprive them. I think, therefore, every farmer can find materials on his own land for manuring purposes.

Q. Suppose he cultivated wheat for market?

A. In that case it would be necessary to make provision for the salts carried off by the grains. The straw, of course, should be composted and returned to the field whence it came; because its ashes contain much potash and phosphorus.

The grains contain very little inorganic matter, the produce of one acre yielding, on combustion, not more than ten or twelve pounds of potash, soda and magnesia, and not more than twelve ounces of lime.

Here I will mention a remarkable fact and one tending to confirm the views I have already expressed.

Gypsum, or plaster of Paris, bone dust and lime do not contain any magnesia; they consist principally of lime of which *wheat* grains require *very little.* Nevertheless they are the most common fertilizers for wheat land.—The supply of *magnesia* must, therefore, come *from the earth; four pounds* to the acre.

Q. Your opinion is that, if an acre of land can yield annually *four pounds magnesia,* for an indefinite term of years, without being artificially replenished, it ought, also, to yield the small quantity of *twelve ounces of lime?*

A. Yes; especially since we know that many fields have been annually deprived of a much larger proportion of lime, for scores of years, without showing the least sign of exhaustion.

Q. You would discourage the employment of commercial manures, then?

A. Yes, if intended to serve as food for the plants. I should not object to their employment as top-dressings or in compost heaps to hasten the decay of vegetable matter. I am convinced, however, that even for these purposes, every plantation furnishes abundant materials.

LESSON FIFTEENTH.

Preparation of Manures.

Q. How would you obtain the largest amount of manure from the animals on your farm ?

A. I should erect good stables, one for each, into which sunshine and rain could never enter. If possible, the floors should be water-proof and about ten inches of the walls, also, from the floors upwards.

Into these I should spread, every week or fortnight, leaves or straw enough to cover the excrements accumulated in that time.

At the end of every two or three months I should remove all the manure from the stables and place it in heaps of convenient size, under sheds so situated as to be protected from the winds as much as possible.

Q. You would have no open lots, then ?

A. No. In such places the sun dries manure, and rain cools it.

Q. Would not your plan consume too much time ?

A. Not at all. Every farmer has spare time enough for such work, and habit would soon render it easy and convenient.

Q. Would you throw soap suds and ashes on these heaps ?

A. No. They would check fermentation by a sudden destruction of the nitrogenous matter. Lime would do the same.

Q. That reminds me of a question which has been puzzling me for some time : How does salt, as a top-dressing, hasten the decay of vegetable matter in the soil? Did you not say that salt is a compound of chlorine and sodium?

A. How salt causes the oxygen to combine more energetically with vegetable matter, is a question I am unable to answer. We know that a piece of iron will rust much faster when occasionally moistened with salt water than it will if the water be fresh. The cause of this is unknown to us; but whatever it is, it is doubtless the same as in the other case.

LESSON SIXTEENTH.

Ploughing; Harrowing, &c.

Q. I think I understand your theory of the action of manures. Now tell me how often and how deep you would plow your corn land after planting?

A. After preparing my land by manuring and pulverizing to the depth of fifteen inches, I would plant my corn. The soil would then be sufficiently porous for the oxygen to penetrate it to its lowest depths; and the gases generated by its decay would maintain it in its porous state. No more deep plowing would be necessary.

Q. If that be true, no more plowing at all would be required.

A. Yes; you recollect there is a crust formed on the surface after a season of dry weather. This must be pulverized.

Q. That crust is seldom over a half-inch thick, and can be broken by something lighter than a plow?

A. Yes; I should use a broad harrow, which could pulverize a whole row by going up and down once. By so doing I could go over my whole crop in less than half the usual time, and would scarcely fatigue my horse.

Q. You would leave, in this way, a portion of grass between the hills of corn undisturbed.

A. True, but the time gained in harrowing would fully suffice for weeding this out with a hoe. Even if this were not done, the advantage of the harrowing is very great, when we consider that the last rows of a crop generally suffer much before the plow can get to them.

Q. Do not heavy rains beat down the surface of the earth and thus lessen its porosity ?

A. Yes; and, of course, the crust thus formed needs pulverizing ; but the harrow will suit just as well as in the other case.

Q. How often would you harrow your fields ?

A. Every time the surface should become encrusted.

LESSON SEVENTEENTH.

Advantages of Improved Modes of Cultivation. Cotton—Space between Rows, &c.

Q. If farmers were to adopt this mode of cultivating their lands, what would be the increase per acre ?

A. Instead of one or two barrels they would gather from eighteen to twenty-three.

Q. Twenty-three !

A. Yes ; some years ago two gentlemen of Newbern, in a contest of agricultural skill, gathered that much per acre, one of them exceeding it by a tub-full or two. Many similar cases are reported in the newspapers.

Q. If all our lands were improved to that extent, every farmer could dispense with about nine-tenths of his present enclosure.

A. Yes, and thus save an immense deal of labor in fencing, ditching, hauling, plowing, harvesting, manuring, &c., &c. He would save time in every conceivable department of his business, and, of course, could pay the more attention to his manures. At the end of the year his horses, his gear and his plows would be in good condition ; his barn full to the joists, and his smoke-house teeming with its abundance of meat and lard.

Q. Would you apply the same mode of culture to cotton ?

A. Substantially the same.

Q. Does the produce of a crop depend, to any degree, on the direction of the rows?

A. Very likely. If the rows lie North and South, in drilled corn, the sun's rays do not reach the earth, but a short time at noon, after the plants become nearly grown; but if they lie East and West, the sun can shine on the ground twice every day, at about ten and two o'clock, and a good while each time.

Q. What space would you allow between corn rows and between the hills in a row?

A. Four feet between rows, and one foot between hills. Thus I could put ten thousand seven hundred and sixty-four plants on one acre.

Q. Might not the rows be placed farther apart and the stalks nearer together with advantage?

A. That would depend on the character of the soil, and experiments made with one crop could determine that question for any farm.

Q. What do you mean by the "character of the soil?"

A. I have reference particularly to its capacity to retain moisture, and consequently to its natural temperature.

Q. Some farmers are careful in choosing seed corn. Do you think it is worth the trouble?

A. Certainly. Everything that grows partakes more or less of the vigor and perfection of the seed from which it springs.

A farmer should gather the largest ears from those stalks which are the most fruitful, and carefully preserve them for seed.

LESSON EIGHTEENTH.

Ditching.

Q. Why are ditches necessary?

A. Because cultivated plants, with few exceptions, cannot thrive with their roots in standing water; and, besides, when the soil is sobbed with water, oxygen cannot penetrate it with sufficient ease, and excessive evaporation diminishes its temperature.

Q. What causes certain localities to be too wet?

A. In some places the *impervious stratum*, before-mentioned, is shaped like a saucer, so that the rain water which soaks down to it cannot escape. When it gets full, therefore, and its surface coincides with that of the earth, the soil is too wet.

A ditch dug from the center of this saucer, in any convenient direction, so as to cut through its side, will drain the land.

In most instances, however, dampness is caused by a difference in the inclinations of the surface and the water-bed. The water, in following the slope of the latter, comes to the surface long before reaching a place where it can readily escape.

Q. How would you remedy this?

A. By a ditch cut at right angles to the direction of the slope and above the places where the water first comes to the surface.

Q. How deep should the ditch be, and where would you have it to empty itself?

A. It should be dug entirely through the upper stratum and extended from its lower extremity to a suitable ravine or other ditch.

LESSON NINETEENTH.

Resting Land.

Q. Why does resting land improve it?

A. There are two reasons: 1st. The grass and weeds which grow on a rested field are a valuable addition to its elements of fertility. 2d. Crab-grass and other weeds of quick growth, are much less troublesome after a year's rest.

Q. How do you account for the latter fact?

A. Crab-grass does not thrive on uncultivated land. It requires the soil to be stirred occasionally. Consequently there is less of its seed on the ground, after a year's rest.