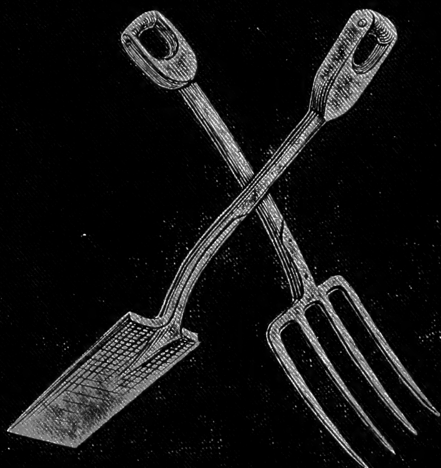

TALKS ON MANURES.

A SERIES OF FAMILIAR AND PRACTICAL TALKS BETWEEN THE AUTHOR AND THE DEACON, THE DOCTOR, AND OTHER NEIGHBORS, ON THE WHOLE SUBJECT OF MANURES AND FERTILIZERS.

BY

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NEW AND ENLARGED EDITION,

INCLUDING A CHAPTER SPECIALLY WRITTEN FOR IT BY SIR JOHN BENNET LAWES, OF ROTHAMSTED, ENGLAND.

NEW YORK:
ORANGE JUDD COMPANY,
751 BROADWAY.
1883.

CONTENTS.

INTRODUCTION TO NEW AND ENLARGED EDITION.

Sir John Bennet Lawes kindly consented to write a Chapter for the new edition of this work. The Deacon, the Doctor, the Squire, Charlie and myself all felt flattered and somewhat bashful at finding ourselves in such distinguished company. I need not say that this new Chapter from the pen of the most eminent English agricultural investigator is worthy of a very careful study. I have read it again and again, and each time with great and renewed interest. I could wish there was more of it. But to the intelligent and well-informed reader this Chapter will be valued not merely for what it contains, but for what it omits. A man who knew less would write more. Sir John goes straight to the mark, and we have here his mature views on one of the most important questions in agricultural science and practice.

Sir John describes a tract of poor land, and tells us that the cheapest method of improving and enriching it is, to keep a large breeding flock of sheep, and feed them American cotton-seed cake. We are pleased to find that this is in accordance with the general teaching of our "Talks," as given in this book several years ago.

When this work was first published, some of my friends expressed surprise that I did not recommend the more extended use of artificial manures. One thing is certain, since that time the use of superphosphate has been greatly on the increase. And it seems clear that its use must be profitable. Where I live, in Western New York, it is sown quite generally on winter wheat, and also on barley and oats in the spring. On corn and potatoes, its use is not so common. Whether this is because its application to these crops is not so easy, or because it does not produce so marked an increase in the yield per acre, I am unable to say.

Our winter wheat is sown here the first, second, or (rarely) the third week in September. We sow from one and a half to two and a quarter bushels per acre. It is almost invariably sown with a drill. The drill has a fertilizer attachment that distributes the superphosphate at the same time the wheat is sown. The superphosphate is not mixed with the wheat, but it drops into the same tubes with the wheat, and is sown with it in the same drill mark. In this way, the superphosphate is deposited where the roots of the young plants can immediately find it. For barley and oats the same method is adopted.

It will be seen that the cost of sowing superphosphate on these crops is merely nominal. But for corn and potatoes, when planted in hills, the superphosphate must be dropped in the hill by hand, and, as we are almost always hurried at that season of the year, we are impatient at anything which will delay planting even for a day. The boys want to go fishing!

This is, undoubtedly, one reason why superphosphate is not used so generally with us for corn as for wheat, barley, and oats. Another reason may be, that one hundred pounds of corn will not sell for anything like as much as one hundred pounds of wheat, barley, and oats.

We are now buying a very good superphosphate, made from Carolina rock phosphate, for about one and a half cents per pound. We usually drill in about two hundred pounds per acre at a cost of three dollars. Now, if this gives us an increase of five bushels of wheat per acre, worth six dollars, we think it pays. It often does far better than this. Last year the wheat crop of Western New York was the best in a third of a century, which is as far back as I have had anything to do with farming here. From all I can learn, it is doubtful if the wheat crop of Western New York has ever averaged a larger yield per acre since the land was first cultivated after the removal of the original forest. Something of this is due to better methods of cultivation and tillage, and something, doubtless, to the general use of superphosphate, but much more to the favorable season.

The present year our wheat crop turned out exceedingly poor. Hundreds of acres of wheat were plowed up, and the land resown, and hundreds more would have been plowed up had it not been for the fact that the land was seeded with timothy grass at the time of sowing the wheat, and with clover in the spring. We do not like to lose our grass and clover.

Dry weather in the autumn was the real cause of the poor yield of wheat this year. True, we had a very trying winter, and a still more trying spring, followed by dry, cold weather. The season was very backward. We were not able to sow anything in the fields before the first of May, and our wheat ought to have been ready to harvest in July. On the first of May, many of our wheat-fields, especially on clay land, looked as bare as a naked fallow.

There was here and there, a good field of wheat. As a rule, it was on naturally moist land, or after a good summer-fallow, sown early. I know of but one exception. A neighboring nursery firm had a very promising field of wheat, which was sown late. But their land is rich and unusually well worked. It is, in fact, in the very highest condition, and, though sown late, the young plants were enabled to make a good strong growth in the autumn.

In such a dry season, the great point is, to get the seed to germinate, and to furnish sufficient moisture and food to enable the young plants to make a strong, vigorous growth of roots in the autumn. I do not say that two hundred pounds of superphosphate per acre, drilled in with the seed, will always accomplish this object. But it is undoubtedly a great help. It does not furnish the nitrogen which the wheat requires, but if it will stimulate the production of roots in the early autumn, the plants will be much more likely to find a sufficient supply of nitrogen in the soil than plants with fewer and smaller roots.

In a season like the past, therefore, an application of two hundred pounds of superphosphate per acre, costing three dollars, instead of giving an increase of five or six bushels per acre, may give us an increase of fifteen or twenty bushels per acre. That is to say, owing to the dry weather in the autumn, followed by severe weather in the winter, the weak plants on the unmanured land may either be killed out altogether, or injured to such an extent that the crop is hardly worth harvesting, while the wheat where the phosphate was sown may give us almost an average crop.

Sir John B. Lawes has somewhere compared the owner of land to the owner of a coal mine. The owner of the coal digs it and gets it to market in the best way he can. The farmer's coal mine consists of plant food, and the object of the farmer is to get this food into such plants, or such parts of plants, as his customers require. It is hardly worth while for the owner of the coal mine to trouble his head about the exhaustion of the supply of coal. His true plan is to dig it as economically as he can, and get it into market. There is a good deal of coal in the world, and there is a good deal of plant food in the earth. As long as the plant food lies dormant in the soil, it is of no value to man. The object of the farmer is to convert it into products which man and animals require.

Mining for coal is a very simple matter, but how best to get the greatest quantity of plant food out of the soil, with the least waste and the greatest profit, is a much more complex and difficult task. Plant food consists of a dozen or more different substances. We have talked about them in the pages of this book, and all I wish to say here is that some of them are much more abundant, and more readily obtained, than others. The three substances most difficult to get at are: nitric acid, phosphoric acid and potash. All these substances are in the soil, but some soils contain much more than others, and their relative proportion varies considerably. The substance which is of the greatest importance, is nitric acid. As a rule, the fertility of a soil is in proportion to the amount of nitric acid which becomes available for the use of plants during the growing season. Many of our soils contain large quantities of nitrogen, united with carbon, but the plants do not take it up in this form. It has to be converted into nitric acid. Nitric acid consists of seven pounds of nitrogen and twenty pounds of oxygen. It is produced by the combustion of nitrogen. Since these "Talks" were published, several important facts have been discovered in regard to how plants take up nitrogen, and especially in regard to how organic nitrogen is converted into nitric acid. It is brought about through the action of a minute fungoid plant. There are several things necessary for the growth of this plant. We must have some nitrogenous substance, a moderate degree of heat, say from seventy to one hundred and twenty degrees, a moderate amount of moisture, and plenty of oxygen. Shade is also favorable. If too hot or too cold, or too wet or too dry, the growth of the plant is checked, and the formation of nitric acid suspended. The presence of lime, or of some alkali, is also necessary for the growth of this fungus and the production of nitric acid. The nitric acid unites with the lime, and forms nitrate of lime, or with soda to form nitrate of soda, or with potash to form nitrate of potash, or salt-petre. A water-logged soil, by excluding the oxygen, destroys this plant, hence one of the advantages of underdraining. I have said that shade is favorable to the growth of this fungus, and this fact explains and confirms the common idea that shade is manure.

The great object of agriculture is to convert the nitrogen of our soils, or of green crops plowed under, or of manure, into nitric acid, and then to convert this nitric acid into profitable products with as little loss as possible. Nitrogen, or rather nitric acid, is the most costly ingredient in plant food, and unfortunately it is very easily washed out of the soil and lost. Perhaps it is absolutely impossible to entirely prevent all loss from leaching; but it is certainly well worth our while to understand the subject, and to know exactly what we are doing. In a new country, where land is cheap, it may be more profitable to raise as large crops as possible without any regard to the loss of nitric acid. But this condition of things does not last long, and it very soon becomes desirable to adopt less wasteful processes.

In Lawes and Gilbert's experiments, there is a great loss of nitric acid from drainage. In no case has as much nitrogen been obtained in the increased crop as was applied in the manure. There is always a loss and probably always will be. But we should do all we can to make the loss as small as possible, consistent with the production of profitable crops.

There are many ways of lessening this loss of nitric acid. Our farmers sow superphosphate with their wheat in the autumn, and this stimulates, we think, the growth of roots, which ramify in all directions through the soil. This increased growth of root brings the plant in contact with a larger feeding surface, and enables it to take up more nitric acid from its solution in the soil. Such is also the case during the winter and early spring, when a good deal of water permeates through the soil. The application of superphosphate, unquestionably in many cases, prevents much loss of nitric acid. It does this by giving us a much greater growth of wheat.

I was at Rothamsted in 1879, and witnessed the injurious effect of an excessive rainfall, in washing out of the soil nitrate of soda and salts of ammonia, which were sown with the wheat in the autumn. It was an exceedingly wet season, and the loss of nitrates on all the different plots was very great. But where the nitrates or salts of ammonia were sown in the spring, while the crops were growing, the loss was not nearly so great as when sown in the autumn.

The sight of that wheat field impressed me, as nothing else could, with the importance of guarding against the loss of available nitrogen from leaching, and it has changed my practice in two or three important respects. I realize, as never before, the importance of applying manure to crops, rather than to the land. I mean by this, that the object of applying manure is, not simply to make land rich, but to make crops grow. Manure is a costly and valuable article, and we want to convert it into plants, with as little delay as possible, which will, directly or indirectly, bring in some money.

Our climate is very different from that of England. As a rule, we seldom have enough rain, from the time corn is planted until it is harvested, to more than saturate the ground on our upland soils. This year is an exception. On Sunday night, May 20, 1883, we had a northeast storm which continued three days. During these three days, from three to five inches of rain fell, and for the first time in many years, at this season, my underdrains discharged water to their full capacity. Had nitrate of soda been sown on bare land previous to this rain, much of it would, doubtless, have been lost by leaching. This, however, is an exceptional case. My underdrains usually do not commence to discharge water before the first of December, or continue later than the first of May. To guard against loss of nitrogen by leaching, therefore, we should aim to keep rich land occupied by some crop, during the winter and early spring, and the earlier the crop is sown in the autumn or late summer, the better, so that the roots will the more completely fill the ground and take up all the available nitrogen within their reach. I have said that this idea had modified my own practice. I grow a considerable quantity of garden vegetables, principally for seed. It is necessary to make the land very rich. The plan I have adopted to guard against the loss of nitrogen is this: As soon as the land is cleared of any crop, after it is too late to sow turnips, I sow it with rye at the rate of one and a half to two bushels per acre. On this rich land, especially on the moist low land, the rye makes a great growth during our warm autumn weather. The rye checks the growth of weeds, and furnishes a considerable amount of succulent food for sheep, during the autumn or in the spring. If not needed for food, it can be turned under in the spring for manure. It unquestionably prevents the loss of considerable nitric acid from leaching during the winter and early spring.

Buckwheat, or millet, is sometimes sown on such land for plowing under as manure, but as these crops are killed out by the winter, they cannot prevent the loss of nitric acid during the winter and spring months. It is only on unusually rich land that such precautions are particularly necessary. It has been thought that these experiments of Lawes and Gilbert afford a strong argument against the use of summer-fallows. I do not think so. A summer-fallow, in this country, is usually a piece of land which has been seeded down one, two, and sometimes three years, with red clover. The land is plowed in May or June, and occasionally in July, and is afterwards sown to winter wheat in September. The treatment of the summer-fallow varies in different localities and on different farms.

Sometimes the land is only plowed once. The clover, or sod, is plowed under deep and well, and the after-treatment consists in keeping the surface soil free from weeds, by the frequent use of the harrow, roller, cultivator or gang-plow. In other cases, especially on heavy clay land, the first plowing is done early in the spring, and when the sod is sufficiently rotted, the land is cross-plowed, and afterwards made fine and mellow by the use of the roller, harrow, and cultivator. Just before sowing the wheat, many good, old-fashioned farmers, plow the land again. But in this section, a summer-fallow, plowed two or three times during the summer, is becoming more and more rare every year.

Those farmers who summer-fallow at all, as a rule, plow their land but once, and content themselves with mere surface cultivation afterwards. It is undoubtedly true, also, that summer fallows of all kinds are by no means as common as formerly. This fact may be considered an argument against the use of summer-fallowing; but it is not conclusive in my mind. Patient waiting is not a characteristic of the age. We are inclined to take risks. We prefer to sow our land to oats, or barley, and run the chance of getting a good wheat crop after it, rather than to spend several months in cleaning and mellowing the land, simply to grow one crop of wheat.

It has always seemed to me entirely unnecessary to urge farmers not to summer-fallow. We all naturally prefer to see the land occupied by a good paying crop, rather than to spend time, money, and labor, in preparing it to produce a crop twelve or fifteen months afterwards. Yet some of the agricultural editors and many of the agricultural writers, seem to take delight in deriding the old-fashioned summer-fallow. The fact that Lawes and Gilbert in England find that, when land contains considerable nitric acid, the water which percolates through the soil to the underdrains beneath, contains more nitrate of lime when the land is not occupied by a crop, than when the roots of growing plants fill the soil, is deemed positive proof that summer-fallowing is a wasteful practice.

If we summer-fallowed for a spring crop, as I have sometimes done, it is quite probable that there would be a loss of nitrogen. But, as I have said before, it is very seldom that any water passes through the soil from the time we commence the summer-fallow until the wheat is sown in the autumn, or for many weeks afterwards. The nitrogen, which is converted into nitric acid by the agency of a good summer-fallow, is no more liable to be washed out of the soil after the field is sown to wheat in the autumn, than if we applied the nitrogen in the form of some readily available manure.

I still believe in summer fallows. If I had my life to live over again, I would certainly summer-fallow more than I have done. I have been an agricultural writer for one-third of a century, and have persistently advocated the more extended use of the summer-fallow. I have nothing to take back, unless it is what I have said in reference to "fall-fallowing." Possibly this practice may result in loss, though I do not think so.

A good summer-fallow, on rather heavy clay land, if the conditions are otherwise favorable, is pretty sure to give us a good crop of wheat, and a good crop of clover and grass afterwards. Of course, a farmer who has nice, clean sandy soil, will not think of summer-fallowing it. Such soils are easily worked, and it is not a difficult matter to keep them clean without summer-fallowing. Such soils, however, seldom contain a large store of unavailable plant food, and instead of summer-fallowing, we had better manure. On such soils artificial manures are often very profitable, though barn-yard manure, or the droppings of animals feeding on the land, should be the prime basis of all attempts to maintain, or increase, the productiveness of such soils.

Since this book was first published, I do not know of any new facts in regard to the important question of, how best to manage and apply our barn-yard manure, so as to make it more immediately active and available. It is unquestionably true, that the same amount of nitrogen in barn-yard manure, will not produce so great an effect as its theoretical value would indicate. There can be no doubt, however, that the better we feed our animals, and the more carefully we save the liquids, the more valuable and active will be the manure.

The conversion of the inert nitrogen of manures and soils, into nitric acid, as already stated, is now known to be produced by a minute fungus. I hope it will be found that we can introduce this *bacterium* into our manure piles, in such a way as to greatly aid the conversion of inert nitrogen into nitrates.

Experiments have been made, and are still continued, at Woburn, under the auspices of the Royal Agricultural Society of England, to ascertain, among other things, whether manure from sheep receiving an allowance of cotton-seed cake is any richer than that from sheep, otherwise fed alike, but having, instead of cotton-seed cake, the same amount of corn meal. We know that such manure contains more nitrogen, and other plant food, than that from the corn meal. But the experiments so far, though they have been continued for several years, do not show any striking superiority of the manure from cotton-seed cake over that from corn meal. I saw the wheat on these differently manured plots in 1879. Dr. Vœlcker and Dr. Gilbert, told me that, one of two plots was dressed with the cotton-seed manure, and the other with the corn meal manure, and they wanted me to say which was the most promising crop. I believe the one I said was the better, was the cotton-seed plot. But the difference was very slight. The truth is that such experiments must be continued for many years before they will prove anything. As I said before, we know that the manure from the cotton-seed cake is richer in nitrogen than that from the corn meal; but we also know that this nitrogen will not produce so great an effect, as a much smaller amount of nitrogen in salts of ammonia, or nitrate of soda.

In going over these experiments, I was struck with the healthy and vigorous appearance of one of the plots of wheat, and asked how it was manured. Dr. Vœlcker called out, "clover, Mr. Harris, clover." In England, as in America, it requires very little observation and experience to convince any one of the value of clover. After what I have said, and what the Deacon, the Doctor, Charley and the Squire have said, in the pages of this book, I hope no one will think that I do not appreciate the great value of red clover as a means of enriching our land. Dr. Vœlcker evidently thought I was skeptical on this point. I am not. I have great faith in the benefits to be derived from the growth of clover. But I do not think it originates fertility; it does not get nitrogen from the atmosphere. Or at any rate, we have no evidence of it. The facts are all the other way. We have discussed this question at considerable length in the pages of this book, and it is not necessary to say more on the subject. I would, however, particularly urge farmers, especially those who are using phosphates freely, to grow as much clover as possible, and feed it out on the farm, or plow it under for manure.

The question is frequently asked, whether the use of phosphates will ultimately impoverish our farms. It may, or it may not. It depends on our general management. Theoretically, the use of a manure furnishing only one element of plant food, if it increases the growth of crops which are sold from the farm, must have a tendency to impoverish the land of the other elements of plant food. In other words, the use of superphosphate furnishing only, or principally, phosphoric acid, lime and sulphuric acid, must have a tendency to impoverish the soil of nitrogen and potash. Practically, however, it need do nothing of the kind. If the land is well cultivated, and if our low, rich, alluvial portions of the farm are drained, and if the hay, grass, clover, straw and fodder crops are retained, the more phosphates we use, the richer and more productive will the farm become. And I think it is a fact, that the farmers who use the most phosphates, are the very men who take the greatest pains to drain their land, cultivate it thoroughly, and make the most manure. It follows, therefore, that the use of phosphates is a national benefit.

Some of our railroad managers take this view of the subject. They carry superphosphate at a low rate, knowing that its use will increase the freight the other way. In other words, they bring a ton of superphosphate from the seaboard, knowing that its use will give them many tons of freight of produce, from the interior to the seaboard. It is not an uncommon thing for two hundred pounds of superphosphate, to give an increase of five tons of turnips per acre. Or, so to speak, the railroad that brings one ton of superphosphate from the seaboard, might, as the result of its use, have fifty tons of freight to carry back again. This is perhaps an exceptionably favorable instance, but it illustrates the principle. Years ago, before the abolition of tolls on the English turnpike roads, carriages loaded with lime, and all other substances intended for manure, were allowed to go free. And our railroads will find it to their interest to transport manures of all kinds, at a merely nominal rate.

Many people will be surprised at the recommendation of Sir John B. Lawes, not to waste time and money in cleaning poor land, before seeding it down to grass. He thinks that if the land is made rich, the superior grasses overgrow the bad grasses and weeds. I have no doubt he is right in this, though the principle may be pushed to an extreme. Our climate, in this country, is so favorable for killing weeds, that the plow and the cultivator will probably be a more economical means of making our land clean, than the liberal use of expensive manures. It depends, doubtless, on the land and on circumstances. It is well to know that manure on grass land, will so increase the growth of the good grasses, as to smother the weeds. Near my house was a piece of land that I wanted to make into a lawn. I sowed it with grass seed, but the weeds smothered it out. I plowed it, and hoed it, and re-seeded it, but still the weeds grew. Mallows came up by the thousand, with other weeds too numerous to mention. It was an eyesore. We mowed the weeds, but almost despaired of ever making a decent bit of grass land out of it. It so happened that, one year, we placed the chicken coops on this miserable weedy spot. The hens and chickens were kept there for several weeks. The feed and the droppings made it look more unsightly than ever, but the next spring, as if by magic, the weeds were gone and the land was covered with dark green luxuriant grass.

In regard to the use of potash as a manure, we have still much to learn. It would seem that our grain crops will use soda, if they cannot get potash. They much prefer the potash, and will grow much more luxuriantly where, in the soil or manure, in addition to the other elements of plant food, potash is abundant. But the increased growth caused by the potash, is principally, if not entirely, straw, or leaves and stem. Nature makes a great effort to propagate the species. A plant of wheat or barley, will produce seed if this is possible, even at the expense of the other parts of the plant.

For grain crops, grown for seed, therefore, it would seem to be entirely unprofitable to use potash as a manure. If the soil contains the other elements of plant food, the addition of potash may give us a much more luxuriant growth of leaves and stem, but no more grain or seed. For hay, or grass or fodder crops, the case is very different, and potash may often be used on these crops to great advantage.

I am inclined to think that considerable nitrate of soda will yet be used in this country for manure. I do not suppose it will pay as a rule, on wheat, corn and other standard grain crops. But the gardener, seed grower, and nurseryman, will find out how to use it with great profit. Our nurserymen say that they cannot use artificial manures with any advantage. It is undoubtedly true that a dressing of superphosphate, sown on a block of nursery trees, will do little good. It never reaches the roots of the plants. Superphosphate can not be washed down deep into the soil. Nitrate of soda is readily carried down, as deep as the water sinks. For trees, therefore, it would seem desirable to apply the superhosphate before they are planted, and plow it under. And the same is true of potash; but nitrate of soda would be better applied as a top-dressing every year, early in the spring.

The most discouraging fact, in Lawes' and Gilbert's experiments, is the great loss of nitrogen. It would seem that, on an average, during the last forty years, about one-half the nitrogen is washed out of the soil, or otherwise lost. I can not but hope and believe that, at any rate in this country, there is no such loss in practical agriculture. In Lawes' and Gilbert's experiments on wheat, this grain is grown year after year, on the same land. Forty annual crops have been removed. No clover is sown with the wheat, and great pains are taken to keep the land clean. The crop is hoed while growing, and the weeds are pulled out by hand. The best wheat season during the forty years, was the year 1863. The poorest, that of 1879; and it so happened, that after an absence of thirty years, I was at Rothamsted during this poor year of 1879. The first thing that struck me, in looking at the experimental wheat, was the ragged appearance of the crop. My own wheat crop was being cut the day I left home, July 15. Several men and boys were pulling weeds out of the experimental wheat, two weeks later. Had the weeds been suffered to grow, Sir John Bennet Lawes tells us, there would be less loss of nitrogen. The loss of nitrogen in 1863, was about twenty-four pounds per acre, and in 1879 fifty pounds per acre—the amount of available nitrogen, applied in each year, being eighty-seven pounds per acre. As I said before, the wheat in 1879 had to me a ragged look. It was thin on the ground. There were not plants enough to take up and evaporate the large amount of water which fell during the wet season. Such a condition of things rarely occurs in this country. We sow timothy with our winter wheat, in the autumn, and red clover in the spring. After the wheat is harvested, we frequently have a heavy growth of clover in the autumn. In such circumstances I believe there would be comparatively little loss of nitrogen.

In the summer-fallow experiments, which have now been continued for twenty-seven years, there has been a great loss of nitrogen. The same remarks apply to this case. No one ever advocates summer-fallowing land every other year, and sowing nothing but wheat. When we summer-fallow a piece of land for wheat, we seed it down with grass and clover.

There is, as a rule, very little loss of nitrogen by drainage while the wheat is growing on the ground, but after the wheat is cut, the grass and clover are pretty sure to take up all the available nitrogen within the range of their roots. This summer-fallow experiment, instead of affording an argument against the use of summer-fallowing, is an argument in its favor. The summer-fallow, by exposing the soil to the decomposing influences of the atmosphere, converts more or less of the inert nitrogenous organic matter into ammonia and nitric acid. This is precisely what a farmer wants. It is just what the wheat crop needs. But we must be very careful, when we render the nitrogen soluble, to have some plant ready to take it up, and not let it be washed out of the soil during the winter and early spring.

We have much poor land in the United States, and an immense area of good land. The poor land will be used to grow timber, or be improved by converting more or less of it, gradually, into pasture, and stocking it with sheep and cattle. The main point is, to feed the sheep or cattle with some rich nitrogenous food, such as cotton-seed cake, malt-sprouts, bran, shorts, mill-feed, refuse beans, or bean-meal made from beans injured by the weevil, or bug. In short, the owner of such land must buy such food as will furnish the most nutriment and make the richest manure at the least cost—taking both of these objects into consideration. He will also buy more or less artificial manures, to be used for the production of fodder crops, such as corn, millet, Hungarian grass, etc. And, as soon as a portion of the land can be made rich enough, he will grow more or less mangel wurzels, sugar beets, turnips, and other root crops. Superphosphate will be found admirably adapted for this purpose, and two, three, or four hundred pounds of cheap potash salts, per acre, can frequently be used on fodder crops, in connection with two or three hundred pounds of superphosphate, with considerable profit. The whole subject is well worthy of careful study. Never in the history of the world has there been a grander opportunity for the application of science to the improvement of agriculture than now.

On the richer lands, the aim of the farmer will be to convert the plant food lying dormant in the soil into profitable crops. The main point is *good tillage*. In many cases weeds now run away with half our crops and all our profits. The weeds which spring up after the grain crops are harvested, are not an unmixed evil. They retain the nitrogen and other plant food, and when turned under make manure for the succeeding crops. But weeds among the growing crop are evil, and only an evil. Thorough plowing is the remedy, accompanied by drainage where needed.

We have an immense number of farms on which there are both good and poor land. In such cases we must adopt a combined system. We must grow large crops on the rich land and use them, at least in part, to make manure for the poorer portions of the farm. Drainage and good tillage will convert much of our low, alluvial lands into a perfect mine of wealth. And much of our high, rolling land consists of strong loam, abounding in plant food. Such land requires little more than thorough tillage, with perhaps two hundred pounds of superphosphate per acre, to enable it to produce good grain crops.

After all is said and done, farming is a business that requires not merely science, but industry, economy, and common sense. The real basis of success is faith, accompanied with good works. I cannot illustrate this better than by alluding to one of my neighbors, a strong, healthy, intelligent, observing and enterprising German, who commenced life as a farm laborer, and is to-day worth at least one hundred thousand dollars, that he has made, not by the advance of suburban property, but by farming, pure and simple. He first rented a farm, and then bought it, and in a few years he bought another farm adjoining the first one, and would to-day buy another if he found one that suited him. He has faith in farming. Some people think he "runs his land," and, in fact, such is the case. He keeps good teams, and good plows, and good harrows, and good rollers, and good cultivators, and good grade Shorthorn cows. He acts as though he believed, as Sir John B. Lawes says, that "the soil is a mine," out of which he digs money He runs his land for all it is worth. He raises wheat, barley, oats, corn, potatoes, and hay, and when he can get a good price for his timothy hay, he draws it to market and sells it. Thorough tillage is the basis of his success. He is now using phosphates for wheat, and will probably increase his herd of cows and make more manure. He has great faith in manure, but acts as though he had still greater faith in good plowing, early sowing, and thorough cultivation.

PREFACE TO FIRST EDITION.

The Printers have got our "Talks on Manures" in type; and the publishers want a Preface.

The Deacon is busy hoeing his corn; the Doctor is gone to Rice Lake, fishing; Charley is cultivating mangels; the Squire is haying, and I am here alone, with a pencil in hand and a sheet of blank paper before me. I would far rather be at work. In fact, I have only just come in from the field.

Now, what shall I say? It will do no good to apologize for the deficiencies of the book. If the critics condescend to notice it at all, nothing I can say will propitiate their favor, or moderate their censure. They are an independent set of fellows! I know them well. I am an old editor myself, and nothing would please me better than to sit down and write a slashing criticism of these "Talks on Manures."

But I am denied that pleasure. The critics have the floor.

All I will say here, is, that the book is what it pretends to be. Some people seem to think that the "Deacon" is a fictitious character. Nothing of the kind. He is one of the oldest farmers in town, and lives on the farm next to me. I have the very highest respect for him. I have tried to report him fully and correctly. Of my own share in the conversations I will say little, and of the Doctor's nothing. My own views are honestly given. I hold myself responsible for them. I may contradict in one chapter what I have asserted in another. And so, probably, has the Deacon. I do not know whether this is or is not the case. I know very well that on many questions "much can be said on both sides"—and very likely the Deacon is sometimes on the south side of the fence and I on the north side; and in the next chapter you may find the Deacon on the north side, and where would you have me go, except to the south side? We cannot see both sides of the fence, if both of us walk on the same side!

I fear some will be disappointed at not finding a particular subject discussed.

I have talked about those things which occupy my own thoughts.

There are some things not worth thinking about. There are others beyond my reach.

I have said nothing about manures for cotton or for the sugar-cane—not because I feel no interest in the matter, but because I have had no experience in the cultivation of these important crops. I might have told what the crops contain, and could have given minute directions for furnishing in manure the exact quantity of plant-food which the crops remove from the soil. But I have no faith in such a system of farming. The few cotton-planters I have had the pleasure of seeing were men of education and rare ability. I cannot undertake to offer them advice. But I presume they will find that, if they desire to increase the growth of the cotton-plant, in nine cases out of ten they can do it, provided the soil is properly worked, by supplying a manure containing available nitrogen, phosphoric acid, and potash. But the *proper proportion* of these ingredients of plant-food must be ascertained by experiment, and not from a mere analysis of the cotton-plant.

I have much faith in artificial manures. They will do great things for American agriculture—directly, and indirectly. Their general use will lead to a higher system of farming—to better cultivation, more root and fodder crops, improved stock, higher feeding, and richer manure. But it has been no part of my object to unduly extol the virtues of commercial manures. That may be left to the manufacturers.

My sympathy is with the farmer, and especially with the farmer of moderate means, who finds that improved farming calls for more and more capital. I would like to encourage such a man. And so, in point of fact, would the Deacon, though he often talks as though a man who tries to improve his farm will certainly come to poverty. Such men as the Deacon are useful neighbors if their doubts, and head-shakings, and shoulder-shruggings lead a young and enthusiastic farmer to put more energy, industry, and economy into his business. It is well to listen to the Deacon—to hear all his objections, and then to keep a sharp look-out for the dangers and difficulties, and *go-ahead.*

TALKS ON MANURES.

CHAPTER I.

FARMING AS A BUSINESS.

"Farming is a poor business," said the Deacon. "Take the corn crop. Thirty bushels per acre is a fair average, worth, at 75 cents per bushel, $22.50. If we reckon that, for each bushel of corn, we get 100 lbs. of stalks, this would be a ton and a half per acre, worth at $5 per ton $7.50."

Total receipts per acre for corn crop		$30 00
Expenses.—Preparing the land for the crop	$5 00	
Planting and seed	1 50	
Cultivating, three times, twice in a row both ways	5 00	
Hoeing twice	3 00	
Cutting up the corn	1 50	
Husking and drawing in the corn	4 00	
Drawing in the stalks, etc.	1 00	
Shelling, and drawing to market	2 00	
Total cost of the crop		$23 00
Profit per acre		$7 00

"And from this," said the Deacon, "we have to deduct interest on land and taxes. I tell you, farming is a poor business."

"Yes," I replied, "*poor* farming is a *very* poor business. But *good* farming, if we have good prices, is as good a business as I want, and withal as pleasant. A good farmer raises 75 bushels of corn per acre, instead of 30. He would get for his crop, including stalks..$75 00

Expenses.—Preparing land for the crop..................	$5 00	
Planting and seed..............................	1 50	
Cultivating..................................	5 00	
Hoeing......................................	3 00	
Cutting up the corn............................	1 50	
Husking and drawing..........................	10 00	
Drawing in the stalks..........................	3 00	
Shelling, etc..................................	6 00	
		$35 00
Profit per acre....................................		$40 00

Take another case, which actually occurred in this neighborhood. The Judge is a good farmer, and particularly successful in raising potatoes and selling them at a good price to hotels and private families. He cultivates very thoroughly, plants in hills, and puts a handful of ashes, plaster, and hen-manure, on the hill.

In 1873, his crop of Peachblows was at the rate of 208 bushels per acre. Of these, 200 bushels were sold at 60 cents per bushel. There were 8 bushels of small potatoes, worth say 12½ cents per bushel, to feed out to stock.

Mr. Sloe, who lives on an adjoining farm, had three acres of Peachblow potatoes the same year. The yield was 100 bushels per acre—of which 25 bushels were not large enough for market, he got 50 cents per bushel for the others.

The account of the two crops stands as follows:

Expenses Per Acre:	*Mr. Sloe*	*Judge.*
Plowing, harrowing, rolling, marking, planting, and covering..............	$ 8 00	$ 8 00
Seed....................................	5 00	5 00
Hoeing, cultivating, etc....................	7 00	10 00
Digging..................................	10 00	10 00
	30 00	33 00
Receipts Per Acre:		
75 bushels, @ 50c..........................	37 50	
25 " @ 12½c..........................	3 12	
	40 62	
200 bushels, @ 60c..........................		120 00
8 " @ 12½c..........................		1 00
		121 00
Profit per acre..........................	$10 62	$98 00

Since then, Mr. Sloe has been making and using more manure, and the year before last (1875) his crop of potatoes averaged over

200 bushels per acre, and on the sandy knolls, where more manure was applied, the yield was at least 250 bushels per acre.

"Nevertheless," said the Deacon, "I do not believe in 'high farming.' It will not pay."

"Possibly not," I replied. "It depends on circumstances; and these we will talk about presently. High farming aims to get large crops every year. *Good* farming produces equally large crops per acre, but not so many of them. This is what I am trying to do on my own farm. I am aiming to get 35 bushels of wheat per acre, 80 bushels of shelled corn, 50 bushels of barley, 90 bushels of oats, 300 bushels of potatoes, and 1,200 bushels of mangel-wurzel per acre, on the average. I can see no way of paying high wages except by raising large crops *per acre.* But if I get these large crops it does not necessarily follow that I am practising 'high farming.'"

To illustrate: Suppose I should succeed in getting such crops by adopting the following plan. I have a farm of nearly 300 acres, one quarter of it being low, alluvial land, too wet for cultivation, but when drained excellent for pasturing cows or for timothy meadows. I drain this land, and after it is drained I dam up some of the streams that flow into it or through it, and irrigate wherever I can make the water flow. So much for the low land.

The upland portion of the farm, containing say 200 acres, exclusive of fences, roads, buildings, garden, etc., is a naturally fertile loam, as good as the average wheat land of Western New York. But it is, or was, badly "run down." It had been what people call "worked to death;" although, in point of fact, it had not been half-worked. Some said it was "wheated to death," others that it had been "oated to death," others that it had been "grassed to death," and one man said to me, "That field has had sheep on it until they have gnawed every particle of vegetable matter out of the soil, and it will not now produce enough to pasture a flock of geese." And he was not far from right—notwithstanding the fact that sheep are thought to be, and are, the best animals to enrich land. But let me say, in passing, that I have since raised on that same field 50 bushels of barley per acre, 33 bushels of Diehl wheat, a great crop of clover, and last year, on a part of it, over 1,000 bushels of mangel-wurzel per acre.

But this is a digression. Let us carry out the illustration. What does this upland portion of the farm need? It needs underdraining, thorough cultivation, and *plenty of manure.* If I had plenty of manure, I could adopt high farming. But where am I to get plenty of manure for 200 acres of land? "Make it," says the

Deacon. Very good; but what shall I make it of? "Make it out of your straw and stalks and hay." So I do, but all the straw and stalks and hay raised on the farm when I bought it would not make as much manure as "high farming" requires for five acres of land. And is this not true of half the farms in the United States to-day? What then, shall we do?

The best thing to do, *theoretically*, is this: Any land that is producing a fair crop of grass or clover, let it lie. Pasture it or mow it for hay. If you have a field of clayey or stiff loamy land, break it up in the fall, and summer-fallow it the next year, and sow it to wheat and seed it down with clover. Let it lie two or three years in clover. Then break it up in July or August, "fall-fallow" it, and sow it with barley the next spring, and seed it down again with clover.

Sandy or light land, that it will not pay to summer-fallow, should have all the manure you can make, and be plowed and planted with corn. Cultivate thoroughly, and either seed it down with the corn in August, or sow it to barley or oats next spring, and seed it down with clover. I say, *theoretically* this is the best plan to adopt. But practically it may not be so, because it may be absolutely necessary that we should raise something that we can sell at once, and get money to live upon or pay interest and taxes. But the gentlemen who so strenuously advocate high farming, are not perhaps often troubled with considerations of this kind. Meeting them, therefore, on their own ground, I contend that in my case "high farming" would not be as profitable as the plan hinted at above.

The rich alluvial low land is to be pastured or mown; the upland to be broken up only when necessary, and when it is plowed to be plowed well and worked thoroughly, and got back again into clover as soon as possible. The hay and pasture from the low land, and the clover and straw and stalks from the upland, would enable us to keep a good many cows and sheep, with more or less pigs, and there would be a big pile of manure in the yard every spring. And when this is once obtained, you can get along much more pleasantly and profitably.

"But," I may be asked, "when you have got this pile of manure can not you adopt high farming?" No. My manure pile would contain say: 60 tons of clover-hay; 20 tons wheat-straw; 25 tons oat, barley, and pea-straw; 40 tons meadow-hay; 20 tons corn-stalks; 20 tons corn, oats, and other grain; 120 tons mangel-wurzel and turnips.

This would give me about 500 tons of well-rotted manure. I should want 200 tons of this for the mangels and turnips, and the 300 tons I should want to top-dress 20 acres of grass land intended for corn and potatoes the next year. My pile of manure, therefore, is all used up on 25 to 30 acres of land. In other words, I use the unsold produce of 10 acres to manure one. Is this "high farming?" I think in my circumstances it is good farming, but it is not high farming. It gives me large crops per acre, but I have comparatively few acres in crops that are sold from the farm.

"High farming," if the term is to have any definite meaning at all, should only be used to express the idea of a farm so managed that the soil is rich enough to produce maximum crops *every year.* If you adopt the system of rotation quite general in this section—say, 1st year, corn on sod; 2d, barley or oats; 3d, wheat; 4th, clover for hay and afterwards for seed; 5th, timothy and clover for hay; and then the 6th year plowed up for corn again—it would be necessary to make the land rich enough to produce say 100 bushels shelled corn, 50 bushels of barley, 40 bushels of wheat, 3 tons clover-hay, and 5 bushels of clover-seed, and 3 tons clover and timothy-hay per acre. This would be *moderate* high farming. If we introduced lucern, Italian rye-grass, corn-fodder, and mangel-wurzel into the rotation, we should need still richer land to produce a maximum growth of these crops. In other words, we should need more manure.

The point I am endeavoring to get at, is this: Where you want a farm to be self-supporting—where you depend solely on the produce of the farm to supply manure—it is a sheer impossibility to adopt high farming *on the whole of your land.* I want to raise just as large crops per acre as the high farmers, but there is no way of doing this, unless we go outside the farm for manure, without raising a smaller area of such crops as are sold from the farm.

I do not wish any one to suppose that I am opposed to high farming. There is occasionally a farm where it may be practised with advantage, but it seems perfectly clear to my mind that as long as there is such an unlimited supply of *land*, and such a limited supply of fertilizers, most of us will find it more profitable to develop the latent stores of plant-food lying dormant in the soil rather than to buy manures. And it is certain that you can not adopt high farming without either buying manure directly, or buying food to feed to animals that shall make manure on the farm.

And you must recollect that high farming requires an increased supply of labor, and hired help is a luxury almost as costly as artificial fertilizers.

We have heard superficial thinkers object to agricultural papers on the ground that they were urging farmers to improve their land and produce larger crops, "while," say they, "we are producing so much already that it will not sell for as much as it costs to produce it." My plan of improved agriculture does not necessarily imply the production of any more wheat or of any more grain of any kind that we sell than we raise at present. I would simply raise it on fewer acres, and thus lessen the expense for seed, cultivation, harvesting, etc. I would raise 30 bushels of wheat per acre every third year, instead of 10 bushels every year.

If we summer-fallowed and plowed under clover in order to produce the 30 bushels of wheat once in three years, instead of 10 bushels every year, no more produce of any kind would be raised. But my plan does not contemplate such a result. On my own farm I seldom summer-fallow, and never plow under clover. I think I can enrich the farm nearly as much by feeding the clover to animals and returning the manure to the land. The animals do not take out more than from five to ten per cent of the more valuable elements of plant-food from the clover. And so my plan, while it produces as much and no more grain to sell, adds greatly to the fertility of the land, and gives an increased production of beef, mutton, wool, butter, cheese, and pork.

"But what is a man to do who is poor and has poor land?" If he has good health, is industrious, economical, and is possessed of a fair share of good common sense, he need have no doubt as to being able to renovate his farm and improve his own fortune.

Faith in good farming is the first requisite. If this is weak, it will be strengthened by exercise. If you have not faith, act as though you had.

Work hard, but do not be a drudge. A few hours' vigorous labor will accomplish a great deal, and encourage you to continued effort. Be prompt, systematic, cheerful, and enthusiastic. Go to bed early and get up when you wake. But take sleep enough. A man had better be in bed than at the tavern or grocery. Let not friends, even, keep you up late; "manners is manners, but still your elth's your elth."

"But what has this to do with good farming?" More than chemistry and all the science of the schools. Agriculture is an art and must be followed as such. Science will help—help enormously—but it will never enable us to dispense with industry. Chemistry throws great light on the art of cooking, but a farmer's wife will roast a turkey better than a Liebig.

When Mr. James O. Sheldon, of Geneva, N. Y., bought his farm, his entire crop of hay the first year was 76 loads. He kept stock, and bought more or less grain and bran, and in eleven years from that time his farm produced 430 loads of hay, afforded pasture for his large herd of Shorthorn cattle, and produced quite as much grain as when he first took it.

Except in the neighborhood of large cities, "high farming" may not pay, owing to the fact that we have so much land. But whether this is so or not, there can be no doubt that the only profitable system of farming is to raise large crops on such land as we cultivate. High farming gives us large crops, and *many of them.* At present, while we have so much land in proportion to population, we must, perhaps, be content with large crops of grain, and few of them. We must adopt the slower but less expensive means of enriching our land from natural sources, rather than the quicker, more artificial, and costly means adopted by many farmers in England, and by market gardeners, seed-growers, and nurserymen in this country. Labor is so high that we can not afford to raise a small crop. If we sow but half the number of acres, and double the yield, we should quadruple our profits. I have made up my mind to let the land lie in clover three years, instead of two. This will lessen the number of acres under cultivation, and enable us to bestow more care in plowing and cleaning it. And the land will be richer, and produce better crops. The atmosphere is capable of supplying a certain quantity of ammonia to the soil in rains and dews every year, and by giving the wheat crop a three years supply instead of two years, we gain so much. Plaster the clover, top-dress it in the fall, if you have the manure, and stimulate its growth in every way possible, and consume all the clover on the land, or in the barn-yard. Do not sell a single ton; let not a weed grow, and the land will certainly improve.

The first object should be to destroy weeds. I do not know how it is in other sections, but with us the majority of farms are completely overrun with weeds. They are eating out the life of the land, and if something is not done to destroy them, even exorbitantly high prices can not make farming profitable. A farmer yesterday was contending that it did not pay to summer-fallow. He has taken a run-down farm, and a year ago last spring he plowed up ten acres of a field, and sowed it to barley and oats. The remainder of the field he summer-fallowed, plowing it four times, and rolling and harrowing thoroughly after each plowing. After the barley and oats were off, he plowed the land once, harrowed it, and sowed Mediterranean wheat. On the summer-fallow he drilled in Diehl wheat. He has just threshed, and got 22 bushels per acre of Mediterranean wheat, after the spring crop, at one plowing, and 26 bushels per acre of Diehl wheat on the summer-fallow. This, he said, would not pay, as it cost him $20 per acre to summer-fallow, and he lost the use of the land for one season. Now this may be all true, and yet it is no argument against summer-fallowing. Wait a few years. Farming is slow work. Mr. George Geddes remarked to me, when I told him I was trying to renovate a run-down farm, "you will find it the work of your life." We ought not to expect a big crop on poor, run-down land, simply by plowing it three or four times in as many months. Time is required for the chemical changes to take place in the soil. But watch the effect on the clover for the next two years, and when the land is plowed again, see if it is not in far better condition than the part not summer-fallowed. I should expect the clover on the summer-fallow to be fully one-third better in quantity, and of better quality than on the other part, and this extra quantity of clover will make an extra quantity of good manure, and thus we have the means of going on with the work of improving the farm.

"Yes," said the Doctor, "and there will also be more clover-roots in the soil."

"But I can not afford to wait for clover, and summer-fallowing," writes an intelligent New York gentleman, a dear lover of good stock, who has bought an exhausted New England farm, "I must have a portion of it producing good crops right off." Very well. A farmer with plenty of money can do wonders in a short time. Set a gang of ditchers to work, and put in underdrains where most needed. Have teams and plows enough to do the work rapidly. As soon as the land is drained and plowed, put on a heavy roller. Then sow 500 lbs. of Peruvian guano per acre broadcast, or its equivalent in some other fertilizer. Follow with a Shares' harrow. This will mellow the surface and cover the guano without disturbing the sod. Follow with a forty-toothed harrow, and roll again, if needed, working the land until there is three or four inches of fine, mellow surface soil. Then mark off the land in rows as straight as an arrow, and plant corn. Cultivate thoroughly, and kill every weed. If the ditchers can not get through until it is too late to plant corn, drill in beans on the last drained part of the field.

Another good crop to raise on a stock farm is corn-fodder. This can be drilled in from time to time as the land can be got ready. Put on half a ton of guano per acre and harrow in, and then mark off the rows three feet apart, and drill in four bushels of corn per acre. Cultivate thoroughly, and expect a great crop. By the last of July, the Ayrshire cows will take kindly to the succulent corn-fodder, and with three or four quarts of meal a day, it will enable each of them to make 10 lbs. of butter a week.

For the pigs, sow a few acres of peas. These will do well on sod-land, sown early or late, or a part early and a part late, as most convenient. Sow broadcast and harrow in, 500 lbs. of Peruvian guano per acre and 200 lbs. of gypsum. Drill in three bushels of peas per acre, or sow broadcast, and cover them with a Shares' harrow. Commence to feed the crop green as soon as the pods are formed, and continue to feed out the crop, threshed or unthreshed, until the middle of November. Up to this time the bugs do comparatively little damage. The pigs will thrive wonderfully on this crop, and make the richest and best of manure.

I have little faith in any attempt to raise root crops on land not previously well prepared. But as it is necessary to have some mangel-wurzel and Swede turnips for the Ayrshire cows and long-wool sheep next winter and spring, select the cleanest and richest land that can be found that was under cultivation last season. If fall plowed, the chances of success will be doubled. Plow the land two or three times, and cultivate, harrow, and roll until it is as mellow as a garden. Sow 400 lbs. of Peruvian guano and 300 lbs. of good superphosphate per acre broadcast, and harrow them in. Ridge up the land into ridges 2½ to 3 ft. apart, with a double mould-board plow. Roll down the ridges with a light roller, and drill in the seed. Sow the mangel-wurzel in May—the earlier the better—and the Swedes as soon afterwards as the land can be thoroughly prepared. Better delay until June rather than sow on rough land.

The first point on such a farm will be to attend to the grass land. This affords the most hopeful chance of getting good returns the first year. But no time is to be lost. Sow 500 lbs. of Peruvian guano per acre on all the grass land and on the clover, with 200 lbs. of gypsum in addition on the latter. If this is sown early enough, so that the spring rains dissolve it and wash it into the soil, great crops of grass may be expected.

"But will it pay?" My friend in New York is a very energetic and successful business man, and he has a real love for farming, and I have no sort of doubt that, taking the New York business and the farm together, they will afford a very handsome profit. Furthermore, I have no doubt that if, after he has drained it, he would cover the whole farm with 500 lbs. of Peruvian guano per acre, or its equivalent, it would pay him better than any other agricultural operation he is likely to engage in. By the time it was on the land the cost would amount to about $20 per acre. If he sells no more grass or hay from the farm than he would sell if he did not use the guano, this $20 may very properly be added to the permanent capital invested in the farm. And in this aspect of the case, I have no hesitation in saying it will pay a high rate of interest. His bill for labor will be as much in one case as in the other; and if he uses the guano he will probably double his crops. His grass lands will carry twenty cows instead of ten, and if he raises the corn-fodder and roots, he can probably keep thirty cows better than he could otherwise keep a dozen; and, having to keep a herdsman in either case, the cost of labor will not be much increased. "But you think it will not pay?" It will probably not pay *him*. I do not think *his* business would pay me if I lived on my farm, and went to New York only once or twice a week. If there is one business above all others that requires constant attention, it is farming—and especially stock-farming. But my friend is right in saying that he cannot afford to wait to enrich his land by clover and summer-fallowing. His land costs too much; he has a large barn and everything requisite to keep a large stock of cattle and sheep. The interest on farm and buildings, and the money expended in labor, would run on while the dormant matter in the soil was slowly becoming available under the influence of good tillage. The large barn must be filled at once, and the only way to do this is to apply manure with an unsparing hand. If he lived on the farm, I should have no doubt that, by adopting this course, and by keeping improved stock, and feeding liberally, he could make money. Perhaps he can find a man who will successfully manage the farm under his direction, but the probabilities are that his present profit and pleasure will come from the gratification of his early love for country life.

CHAPTER II.

WHAT IS MANURE?

"What is the good of asking such a question as that?" said the Deacon; "we all know what manure is."

"Well, then," I replied, "tell us what it is?"

"*It is anything that will make crops grow better and bigger,*" replied the Deacon.

"That is not a bad definition," said I; "but let us see if it is a true one. You have two rows of cabbage in the garden, and you water one row, and the plants grow bigger and better. Is *water* manure? You cover a plant with a hand-glass, and it grows bigger and better. Is a hand-glass manure? You shelter a few plants, and they grow bigger and better. Is shelter manure? You put some pure sand round a few plants, and they grow bigger and better. Is pure sand manure? I think we shall have to reject the Deacon's definition."

Let us hear what the Doctor has to say on the subject.

"Manure," replied the Doctor, "is the *food of plants.*"

"That is a better definition," said I; "but this is really not answering the question. You say manure is plant-food. But what is plant-food?"

"Plant-food," said the Doctor, "is composed of twelve elements, and, possibly, sometimes one or two more, which we need not here talk about. Four of these elements are gases, oxygen, hydrogen, carbon, and nitrogen. When a plant or animal is burnt, these gases are driven off. The ashes which remain are composed of potash, soda, lime, and magnesia; sulphuric acid, phosphoric acid, chlorine, and silica. In other words, the 'food of plants' is composed of four organic, or gaseous elements, and eight inorganic, or mineral elements, of which four have acid and four alkaline properties."

"Thank you, Doctor," said the Deacon, "I am glad to know what manure is. It is the food of plants, and the food of plants is composed of four gases, four acid and four alkaline elements. I seem to know all about it. All I have wanted to make my land rich was plenty of manure, and now I shall know where to get it—oxygen, hydrogen, carbon, and nitrogen; these four atmospheric elements. Then potash, soda, magnesia, and lime. I know what these four are. Then sulphur, phosphorous, silica (sand,) and chlorine (salt). I shall soon have rich land and big crops."

Charley, who has recently come home from college, where he has been studying chemistry, looked at the Deacon, and was evidently puzzled to understand him. Turning to the Doctor, Charley asked modestly if what the Doctor had said in regard to the composition of plant-food could not be said of the composition of all our animals and plants.

"Certainly," replied the Doctor, "all our agricultural plants and all our animals, man included, are composed of these twelve elements, oxygen, hydrogen, carbon, and nitrogen; phosphorus, sulphur, silica, chlorine, potash, soda, magnesia, and lime."

Charley said something about lime, potash, and soda, not being "elements;" and something about silica and chlorine not being found in animals.

"Yes," said I, "and he has left out *iron*, which is an important constituent of all our farm crops and animals." Neither the Doctor nor the Deacon heard our remarks. The Deacon, who loves an argument, exclaimed: "I thought I knew all about it. You told us that manure was the food of plants, and that the food of plants was composed of the above twelve elements; and now you tell us that man and beast, fruit and flower, grain and grass, root, stem, and branch, all are composed or made up of these same dozen elements. If I ask you what bread is made of, you say it is composed of the dozen elements aforesaid. If I ask what wheat-straw is made of, you answer, the *dozen*. If I ask what a thistle is made of, you say the dozen. There are a good many milk-weeds in my strawberry patch, and I am glad to know that the milk-weed and the strawberry are both composed of the same dozen elements. Manure is the food of plants, and the food of plants is composed of the above dozen elements, and every plant and animal that we eat is also composed of these same dozen elements, and so I suppose there is no difference between an onion and an omelet, or between bread and milk, or between mangel-wurzel and manure."

"The difference," replied the Doctor, "is one of proportion. Mangels and manure are both composed of the same elements. In fact, mangels make good manure, and good manure makes good mangels."

The Deacon and the Doctor sat down to a game of backgammon, and Charley and I continued the conversation more seriously.

CHAPTER III.

SOMETHING ABOUT PLANT-FOOD.

"The Doctor is in the main correct," said I; "but he does not fully answer the question, 'What is manure?' To say that manure is plant-food, does not cover the whole ground. All soils on which plants grow, contain more or less plant-food. A plant can not create an atom of potash. It can not get it from the atmosphere. We find potash in the plant, and we know that it got it from the soil, and we are certain, therefore, that the soil contains potash. And so of all the other mineral elements of plants. A soil that will produce a thistle, or a pig-weed, contains plant-food. And so the definition of the Doctor is defective, inasmuch as it makes no distinction between soil and manure. Both contain plant-food."

"What is your definition of manure?" asked Charley; "it would seem as though we all knew what manure was. We have got a great heap of it in the yard, and it is fermenting nicely."

"Yes," I replied, "we are making more manure on the farm this winter than ever before. Two hundred pigs, 120 large sheep, 8 horses, 11 cows, and a hundred head of poultry make considerable manure; and it is a good deal of work to clean out the pens, pile the manure, draw it to the field, and apply it to the crops. We ought to know something about it; but we might work among manure all our lives, and not know what manure is. At any rate, we might not be able to define it accurately. I will, however, try my hand at a definition.

"Let us assume that we have a field that is free from stagnant water at all seasons of the year; that the soil is clean, mellow, and well worked seven inches deep, and in good order for putting in a crop. What the coming '*season*' will be we know not. It may be what we call a hot, dry summer, or it may be cool and moist, or it may be partly one and partly the other. The 'season' is a great element of uncertainty in all our farming calculations; but we know that we shall have a season of some kind. We have the promise of seed-time and harvest, and we have never known the promise to fail us. Crops, however, vary very much, according to the season; and it is necessary to bear this fact in mind. Let us say that the sun and heat, and rain and dews, or what we call 'the season,' is capable of producing 50 bushels of wheat per acre, but that the soil I have described above, does not produce over 20 bushels per acre. There is no mechanical defect in the soil. The seed is good, it is put in properly, and at the right time, and in the best manner. No weeds choke the wheat plants or rob them of their food; but that field does not produce as much wheat by 30 bushels per acre as the *season* is capable of producing. Why? The answer is evident. *Because the wheat plants do not find food enough in the soil.* Now, anything that will furnish this food, anything that will cause that field to produce what the climate or season is capable of producing, is manure. A gardener may increase his crops by artificial heat, or by an increased supply of water, but this is not manure. The effect is due to improved climatic conditions. It has nothing to do with the question of manure. We often read in the agricultural papers about '*shade* as manure.' We might just as well talk about *sunlight* as 'manure.' The effects observed should be referred to modifications of the climate or season; and so in regard to mulching. A good mulch may often produce a larger increase of growth than an application of manure. But mulch, proper, is not manure. It is climate. It checks evaporation of moisture from the soil. We might as well speak of rain as manure as to call a mulch manure. In fact, an ordinary shower in summer is little more than a mulch. It does not reach the roots of plants; and yet we see the effect of the shower immediately in the increased vigor of the plants. They are full of sap, and the drooping leaves look refreshed. We say the rain has revived them, and so it has; but probably not a particle of the rain has entered into the circulation of the plant. The rain checked evaporation from the soil and from the leaves. A cool night refreshes the plants, and fills the leaves with sap, precisely in the same way. All these fertilizing effects, however, belong to climate. It is inaccurate to associate either mulching, sunshine, shade, heat, dews, or rain, with the question of manure, though the effect may in certain circumstances be precisely the same."

Charley evidently thought I was wandering from the point. "You think, then," said he, "manure is *plant-food that the soil needs?*"

"Yes," said I, "that is a very good definition—very good, indeed, though not absolutely accurate, because manure is manure, whether a particular soil needs it or not." Unobserved by us, the Deacon and the Doctor had been listening to our talk.—"I would like," said the Deacon, "to hear you give a better definition than Charley has given."—"Manure," said I, "is anything containing an element or elements of plant-food, which, if the soil needed it, would, if supplied in sufficient quantity, and in an available condition, produce, according to soil, season, climate, and variety, a maximum crop."

CHAPTER IV.

NATURAL MANURE.

We often hear about "natural" manure. I do not like the term, though I believe it originated with me. It is not accurate; not definite enough.

"I do not know what you mean by natural manure," said the Deacon, "unless it is the droppings of animals."—"To distinguish them, I suppose," said the Doctor, "from artificial manures, such as superphosphate, sulphate of ammonia, and nitrate of soda."—"No; that is not how I used the term. A few years ago, we used to hear much in regard to the 'exhaustion of soils.' I thought this phrase conveyed a wrong idea. When new land produces large crops, and when, after a few years, the crops get less and less, we were told that the farmers were exhausting their land. I said, no; the farmers are not exhausting the *soil;* they are merely exhausting the accumulated plant-food in the soil. In other words, they are using up the *natural manure.*

"Take my own farm. Fifty years ago, it was covered with a heavy growth of maple, beech, black walnut, oak, and other trees. These trees had shed annual crops of leaves for centuries. The leaves rot on the ground; the trees also, age after age. These leaves and other organic matter form what I have called natural manure. When the land is cleared up and plowed, this natural manure decays more rapidly than when the land lies undisturbed; precisely as a manure-pile will ferment and decay more rapidly if turned occasionally, and exposed to the air. The plowing and cultivating renders this natural manure more readily available. The leaves decompose, and furnish food for the growing crop."

EXHAUSTION OF THE SOIL.

"You think, then," said the Doctor, "that when a piece of land is cleared of the forest, harrowed, and sown to wheat; plowed and planted to corn, and the process repeated again and again, until the land no longer yields profitable crops, that it is the 'natural manure,' and not the soil, that is exhausted?"

"I think the *soil*, at any rate, is not exhausted, and I can easily conceive of a case where even the natural manure is very far from being all used up."

"Why, then," asked the Deacon, "is the land so poor that it will scarcely support a sheep to the acre?"

"Simply because the natural manure and other plant-food which the soil contains is not in an available condition. It lies dead and inert. It is not soluble, and the roots of the plants cannot get enough of it to enable them to thrive; and in addition to this, you will find as a matter of fact that these poor 'exhausted' farms are infested with weeds, which rob the growing crops of a large part of the scanty supply of available plant-food."

"But these weeds," said the Deacon, "are not removed from the farm. They rot on the land; nothing is lost."

"True," said I, "but they, nevertheless, rob the growing crops of available plant-food. The annual supply of plant-food, instead of being used to grow useful plants, is used to grow weeds."

"I understand that," said the Deacon, "but if the weeds are left on the land, and the useful plants are sold, the farmer who keeps his land clean would exhaust his land faster than the careless farmer who lets his land lie until it is overrun with thistles, briars, and pig-weed. You agricultural writers, who are constantly urging us to farm better and grow larger crops, seem to overlook this point. As you know, I do not take much stock in chemical theories as applied to agriculture, but as you do, here is a little extract I cut from an agricultural paper, that seems to prove that the better you work your land, and the larger crops you raise, the sooner you exhaust your land."

The Deacon put on his spectacles, drew his chair nearer the lamp on the table, and read the following:

"There is, on an average, about one-fourth of a pound of potash to every one hundred pounds of soil, and about one-eighth of a pound of phosphoric acid, and one-sixteenth of a pound of sulphuric acid. If the potatoes and the tops are continually removed from the soil, it will soon exhaust the potash. If the wheat and straw are removed, it will soon exhaust the phosphate of lime; if corn and the stalks, it will soon exhaust the sulphuric acid. Unless there is a rotation, or the material the plant requires is supplied from abroad, your crops will soon run out, though the soil will continue rich for other plants."

"That extract," said I, "carries one back twenty-five years. We used to have article after article in this strain. We were told that 'always taking meal out of the tub soon comes to the bottom,' and always taking potash and phosphoric acid from the soil will soon exhaust the supply. But, *practically*, there is really little danger of our exhausting the land. It does not pay. The farmer's resources will be exhausted long before he can exhaust his farm."

"Assuming," said the Doctor, who is fond of an argument, "that the above statement is true, let us look at the facts. An acre of soil, 12 inches deep, would weigh about 1,600 tons; and if, as the writer quoted by the Deacon states, the soil contains 4 ozs. of potash in every 100 lbs. of soil, it follows that an acre of soil, 12 inches deep, contains 8,000 lbs. of potash. Now, potatoes contain about 20 per cent of dry matter, and this dry matter contains, say, 4 per cent of ash, half of which is potash. It follows, therefore, that 250 bushels of potatoes contain about 60 lbs. of potash. If we reckon that the tops contain 20 lbs. more, or 80 lbs. in all, it follows that the acre of soil contains potash enough to grow an *annual* crop of 250 bushels of potatoes per acre for one hundred years."

"I know farmers," said Charley, "who do not get over 50 bushels of potatoes per acre, and in that case the potash would last five hundred years, as the weeds grown with the crop are left on the land, and do not, according to the Deacon, exhaust the soil."

"Good for you, Charley," said the Doctor. "Now let us see about the phosphoric acid, of which the soil, according to the above statement, contains only half as much as it contains of potash, or 4,000 lbs. per acre.

"A crop of wheat of 30 bushels per acre," continued the Doctor, "contains in the grain about 26 lbs. of ash, and we will say that half of this ash is phosphoric acid, or 13 lbs. Allowing that the straw, chaff, etc., contain 7 lbs. more, we remove from the soil in a crop of wheat of 30 bushels per acre, 20 lbs. of phosphoric acid, and so, according to the above estimate, an acre of soil contains phosphoric acid to produce annually a crop of wheat and straw of 30 bushels per acre for *two hundred years.*

"The writer of the paragraph quoted by the Deacon," continued the Doctor, "selected the crops and elements best suited to his purpose, and yet, according to his own estimate, there is sufficient potash and phosphoric acid in the first 12 inches of the soil to enable us to raise unusually large crops until the next Centennial in 1976.

"But let us take another view of the subject," continued the Doctor. "No intelligent farmer removes all the potatoes *and tops*, all the wheat, straw, and chaff, or all the corn and stalks from his farm. According to Dr. Salisbury, a crop of corn of 75 bushels per acre removes from the soil 600 lbs. of ash, but the *grain* contains only 46 lbs. The other 554 lbs. is contained in the stalks, etc., all of which are usually retained on the farm. It follows from this, that when only the grain is sold off the farm, it takes more than thirteen crops to remove as much mineral matter from the soil as is contained in the whole of one crop. Again, the ash of the grain contains less than 3 per cent of sulphuric acid, so that the 46 lbs. of ash, in 75 bushels of corn, contains less than 1½ lbs. of sulphuric acid, and thus, if an acre of soil contains 2,000 lbs. of sulphuric acid, we have sufficient for an annual crop of 75 bushels per acre for fifteen hundred years!

"As I said before," continued the Doctor, "intelligent farmers seldom sell their straw, and they frequently purchase and consume on the farm nearly as much bran, shorts, etc., as is sent to market with the grain they sell. In the 'Natural History of New York,' it is stated that an acre of wheat in Western New York, of 30 bushels per acre, including straw, chaff, etc., removes from the soil 144 lbs. of mineral matter. Genesee wheat usually yields about 80 per cent. of flour. This flour contains only 0.7 per cent of mineral matter, while fine middlings contain 4 per cent; coarse middlings, 5½ per cent; shorts, 8 per cent, and bran 8½ per cent of mineral matter or ash. It follows from this, that out of the 144 lbs. of mineral matter in the crop of wheat, less than 10 lbs. is contained in the flour. The remaining 134 lbs. is found in the straw, chaff, bran, shorts, etc., which a good farmer is almost sure to feed out on his farm. But even if the farmer feeds out none of his wheat-bran, but sells it all with his wheat, the 30 bushels of wheat remove from the soil only 26 lbs. of mineral matter; and it would take more than five crops to remove as much mineral matter as one crop of wheat and straw contains. Allowing that half the ash of wheat is phosphoric acid, 30 bushels remove only 13 lbs. from the soil, and if the soil contains 4,000 lbs., it will take three hundred and seven crops, of 30 bushels each, to exhaust it."

"That is to say," said Charley, "if all the straw and chaff is retained on the farm, and is returned to the land without loss of phosphoric acid."

"Yes," said the Doctor, "and if all the bran and shorts, etc., were retained on the farm, it would take eight hundred crops to exhaust the soil of phosphoric acid; and it is admitted that of all the elements of plant-food, phosphoric acid is the one first to be exhausted from the soil."

I have sold some timothy hay this winter, and propose to do so whenever the price suits. But some of my neighbors, who do not hesitate to sell their own hay, think I ought not to do so, because I "write for the papers"! It ought to satisfy them to know that I bring back 30 cwt. of bran for every ton of hay I sell. My rule is to sell nothing but wheat, barley, beans, potatoes, clover-seed, apples, wool, mutton, beef, pork, and butter. Everything else is consumed on the farm—corn, peas, oats, mustard, rape, mangels, clover, straw, stalks, etc. Let us make a rough estimate of how much is sold and how much retained on a hundred-acre farm, leaving out the potatoes, beans, and live-stock. We have say:

Sold.		
15 acres wheat, @ 40 bushels per acre	18	tons.
5 " barley, @ 50 " "	6	"
15 " clover seed, 4 " "	1¾	ton.
Total sold	25¾	tons.
Retained on the farm.		
15 acres corn, @ 80 bushels per acre	33½	tons.
Corn stalks from do	40	"
5 acres barley straw	8	"
10 " oats and peas, equal 80 bushels of oats	12¾	"
Straw from do	20	"
15 acres wheat-straw	25	"
15 " clover-hay	25	"
Clover-seed straw	10	"
15 acres pasture and meadow, equal 40 tons hay	40	"
5 " mustard, equal 10 tons hay	10	"
5 " rape, equal 10 tons hay	10	"
5 " mangels, 25 tons per acre, equal to 3 tons dry	15	"
Leaves from do	3	"
Total retained on the farm	252¼	tons.

It would take a good many years to exhaust any ordinary soil by such a course of cropping. Except, perhaps, the sandy knolls, I think there is not an acre on my farm that would be exhausted in ten thousand years, and as some portions of the low alluvial soil will grow crops without manure, there will be an opportunity to give the poor, sandy knolls more than their share of plant-food. In this way, notwithstanding the fact that we sell produce and bring nothing back, I believe the whole farm will gradually increase in productiveness. The plant-food annually rendered available from the decomposition and disintegration of the inert organic and mineral matter in the soil, will be more than equal to that exported from the farm. If the soil becomes deficient in anything, it is likely that it will be in phosphates, and a little superphosphate or bone-dust might at any rate be profitably used on the rape, mustard, and turnips.

The point in good farming is to develop from the latent stores in the soil, and to accumulate enough available plant-food for the production of the largest possible yield of those crops which we sell. In other words, we want enough available plant-food in the soil to grow 40 bushels of wheat and 50 bushels of barley. I think the farmer who raises 10 tons for every ton he sells, will soon reach this point, and when once reached, it is a comparatively easy matter to maintain this degree of fertility.

WHY OUR CROPS ARE SO POOR.

"If the soil is so rich in plant-food," said the Deacon, "I again ask, why are our crops so poor?"

The Deacon said this very quietly. He did not seem to know that he had asked one of the most important questions in the whole range of agricultural science. It is a fact that a soil may contain enough plant-food to produce a thousand large crops, and yet the crops we obtain from it may be so poor as hardly to pay the cost of cultivation. The plant-food is there, but the plants cannot get at it. It is not in an available condition; it is not soluble. A case is quoted by Prof. Johnson, where a soil was analyzed, and found to contain to the depth of one foot 4,652 lbs. of nitrogen per acre, but only 63 lbs. of this was in an available condition. And this is equally true of phosphoric acid, potash, and other elements of plant-food. No matter how much plant-food there may be in the soil, the only portion that is of any immediate value is the small amount that is annually available for the growth of crops.

HOW TO GET LARGER CROPS.

"I am tired of so much talk about plant-food," said the Deacon; "what we want to know is how to make our land produce larger crops of wheat, corn, oats, barley, potatoes, clover, and grass."

This is precisely what I am trying to show. On my own farm, the three leading objects are (1) to get the land drained, (2) to make it clean and mellow, and (3) to get available nitrogen for the cereal crops. After the first two objects are accomplished, the measure of productiveness will be determined by the amount of available nitrogen in the soil. How to get available nitrogen, therefore, is my chief and ultimate object in all the operations on the farm, and it is here that science can help me. I know how to get nitrogen, but I want to get it in the cheapest way, and then to be sure that I do not waste it.

There is one fact fully established by repeated experiment and general experience—that 80 lbs. of available nitrogen per acre, applied in manure, will almost invariably give us a greatly increased yield of grain crops. I should expect, on my farm, that on land which, without manure, would give me 15 bushels of wheat per acre, such a dressing of manure would give me, in a favorable season, 35 or 40 bushels per acre, with a proportional increase of straw; and, in addition to this, there would be considerable nitrogen left for the following crop of clover. Is it not worth while making an earnest effort to get this 80 lbs. of available nitrogen?

I have on my farm many acres of low, mucky land, bordering on the creek, that probably contain several thousand pounds of nitrogen per acre. So long as the land is surcharged with water, this nitrogen, and other plant-food, lies dormant. But drain it, and let in the air, and the oxygen decomposes the organic matter, and ammonia and nitric acid are produced. In other words, we get *available* nitrogen and other plant-food, and the land becomes capable of producing large crops of corn and grass; and the crops obtained from this low, rich land, will make manure for the poorer, upland portions of the farm.

CHAPTER V.

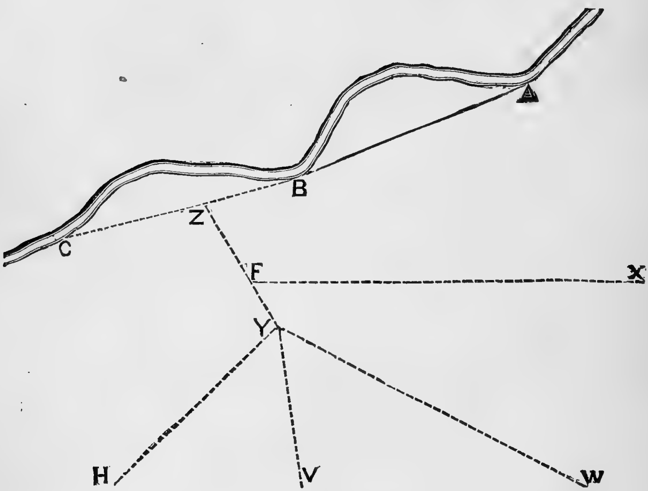
SWAMP-MUCK OR PEAT AS MANURE.

"It would pay you," said the Deacon, "to draw out 200 or 300 loads of muck from the swamp every year, and compost it with your manure."

This may or may not be the case. It depends on the composition of the muck, and how much labor it takes to handle it.

"What you should do," said the Doctor, "is to commence at the creek, and straighten it. Take a gang of men, and be with them with yourself, or get a good foreman to direct operations. Commence at *a*, and straighten the creek to *b*, and from *b* to *c* (see map on next page). Throw all the rich, black muck in a heap by itself, separate from the sand. You, or your foreman, must be there, or you will not get this done. A good ditcher will throw out a great mass of this loose muck and sand in a day; and you want him to dig, not think. You must do the thinking, and tell him which is muck, and which is only sand and dirt. When thrown up, this muck, in our dry, hot climate, will, in the course of a few months, part with a large amount of water, and it can then be drawn to the barns and stables, and used for bedding, or for composting with manure. Or if you do not want to draw it to the barn, get some refuse lime from the lime-kiln, and mix it with the muck after it has been thrown up a few weeks, and is partially dry. Turn over the heap, and put a few bushels of lime to every cord of the muck, mixing the lime and muck together, leaving the heap in a compact form, and in good shape, to shed the rain.

"When you have straightened, and cleaned out, and deepened the creek," continued the Doctor, "commence at *z* on the new creek, and cut a ditch through the swamp to *y*. Throw the muck on one side, and the sand on the other. This will give you some



MAP OF CREEK.

good, rich muck, and at the same time drain your swamp. Then cut some *under-drains* from *y* towards the higher land at *w*, *v*, and *h*, and from *f* to *x*. These will drain your land, and set free the inert plant-food, and such crops of timothy as you will get from this swamp will astonish the natives, and your bill for medical attendance and quinine will sink to zero."

The Doctor is right. There is money and health in the plan.

Prof. S. W. Johnson, as chemist to the Conn. State Ag. Society, made accurate analyses of 33 samples of peat and muck sent him by gentlemen from different parts of the State. The amount of potential ammonia in the chemically dry peat was found to vary from 0.58 in the poorest, to 4.06 per cent in the richest samples. In other words, one deposit of muck may contain seven times as much nitrogen as another, and it would be well before spending much money in drawing out muck for manure to send a sample of it to some good chemist. A bed of swamp-muck, easily accessible, and containing 3 per cent of nitrogen, would be a mine of wealth to any farmer. One ton of such muck, dry, would contain more nitrogen than 7 tons of straw.

"It would be capital stuff," said the Deacon, "to put in your pig-pens to absorb the urine. It would make rich manure."

"That is so," said I, "and the weak point in my pig-breeding is the want of sufficient straw. Pigs use up more bedding than any other animals. I have over 200 pigs, and I could use a ton of dry muck to each pig every winter to great advantage. The pens would be drier, the pigs healthier, and the manure richer."

The Doctor here interrupted us. "I see," said he, "that the average amount of ammonia in the 33 samples of dry peat analyzed by Professor Johnson is 2.07 per cent. I had no idea that muck was so rich. Barn-yard manure, or the manure from the horse stables in the cities, contains only half a per cent (0.5) of ammonia, and it is an unusually rich manure that contains one per cent. We are safe in saying that a ton of dry muck, on the average, contains at least twice as much potential ammonia as the average of our best and richest stable-manure."

CHAPTER VI.

WHAT IS POTENTIAL AMMONIA?

"You say," said the Deacon, "that dry muck contains twice as much '*potential ammonia*' as manure?"

"Yes," said the Doctor, "it contains three or four times as much as the half-rotted straw and stalks you call manure."

"But what do you mean," asked the Deacon, "by '*potential* ammonia?'"

"It is a term," said the Doctor, "we used to hear much more frequently than we do now. Ammonia is composed of 14 lbs. of nitrogen and 3 lbs. of hydrogen; and if, on analysis, a guano or other manure was found to contain, in whatever form, 7 per cent of nitrogen, the chemist reported that he found in it 8½ per cent of 'potential' ammonia. Dried blood contains no ammonia, but if it contained 14 per cent of nitrogen, the chemist would be justified in saying it contained 17 per cent of potential ammonia, from the fact that the dried blood, by fermentation, is capable of yielding this amount of ammonia. We say a ton of common horse-manure contains 10 or 12 lbs. of potential ammonia. If perfectly fresh, it may not contain a particle of ammonia; but it contains nitrogen enough to produce, by fermentation, 10 or 12 lbs. of ammonia. And when it is said that dry swamp-muck contains, on the average, 2.07 per cent of potential ammonia, it simply means that it contains nitrogen enough to produce this amount of ammonia. In point of fact, I suppose muck, when dug fresh from the swamp, contains no ammonia. Ammonia is quite soluble in water, and if there was any ammonia in the swamp-muck, it would soon be washed out. The nitrogen, or 'potential ammonia,' in the muck exists in an inert, insoluble form, and before the muck will yield up this nitrogen to plants, it is necessary, in some way, to ferment or decompose it. But this is a point we will discuss at a future meeting."

CHAPTER VII.

TILLAGE IS MANURE.

The Doctor has been invited to deliver a lecture on manure before our local Farmers' Club. "The etymological meaning of the word manure," he said, "is *hand labor*, from *main*, hand, and *ouvrer*, to work. To manure the land originally meant to cultivate it, to hoe, to dig, to plow, to harrow, or stir it in any way so as to expose its particles to the oxygen of the atmosphere, and thus render its latent elements assimilable by plants.

"When our first parent," he continued, "was sent forth from the Garden of Eden to till the ground from whence he was taken, he probably did not know that the means necessary to kill the thorns and thistles enhanced the productiveness of the soil, yet such was undoubtedly the case.

"The farmer for centuries was simply a 'tiller of the ground.' Guano, though formed, according to some eminent authorities, long ages before the creation of man, was not then known. The coprolites lay undisturbed in countless numbers in the lias, the greensand, and the Suffolk crag. Charleston phosphates were unknown. Superphosphate, sulphate of ammonia, nitrate of soda, and kainit were not dreamed of. Nothing was said about the mineral manure theory, or the exhaustion of the soil. There were no frauds in artificial fertilizers; no Experiment Stations. The earth, fresh from the hands of its Creator, needed only to be 'tickled with a hoe to laugh with a harvest.' Nothing was said about the value of the manure obtained from the consumption of a ton of oil-cake, or malt-combs, or bran, or clover-hay. For many centuries, the hoe, the spade, and the rake constituted Adam's whole stock in trade.

"At length," continued the Doctor, "a great discovery was made. A Roman farmer—probably a prominent Granger—stumbled on a mighty truth. Manuring the land—that is, hoeing and cultivating it—increased its fertility. This was well known—had been known for ages, and acted upon; but this Roman farmer, Stercutius, who was a close observer, discovered that the *droppings of animals* had the same effect as hoeing. No wonder these idolatrous people voted him a god. They thought there would be no more old-fashioned manuring; no more hoeing.

"Of course they were mistaken," continued the Doctor, "our arable land will always need plowing and cultivating to kill weeds. Manure, in the sense in which we now use the term, is only a partial substitute for tillage, and tillage is only a partial substitute for manure; but it is well to bear in mind that the words mean the same thing, and the effects of both are, to a certain extent, identical. Tillage is manure, and manure is tillage."

CHAPTER VIII.

SUMMER-FALLOWING.

This is not the place to discuss the merits, or demerits, of fallowing. But an intelligent Ohio farmer writes me:—"I see that you recommend fallow plowing, what are your reasons? Granting that the *immediate* result is an increased crop, is not the land impoverished? Will not the thorough cultivation of corn, or potatoes, answer as well?" And a distinguished farmer, of this State, in a recent communication expressed the same idea—that summer-fallowing would soon impoverish the land. But if this is the case, the fault is not in the practice of summer-fallowing, but in growing too many grain crops, and selling them, instead of consuming them on the farm. Take two fields; summer-fallow one, and sow it to wheat. Plant the other to corn, and sow wheat after it in the fall. You get, say 35 bushels of wheat per acre from the summer-fallow. From the other field you get, say, 30 bushels of shelled corn per acre, and 10 bushels of wheat afterwards. Now, where a farmer is in the habit of selling all his wheat, and consuming all his corn on the farm, it is evident that the practice of summer-fallowing will impoverish the soil more rapidly than the system of growing corn followed by wheat—and for the simple reason that more wheat is sold from the farm. If no more grain is sold in one case than in the other, the summer-fallowing will not impoverish the soil any more than corn growing.

My idea of fallowing is this:—The soil and the atmosphere furnish, on good, well cultivated land, plant-food sufficient, say, for 15 bushels of wheat per acre, *every year*. It will be sometimes more, and sometimes less, according to the season and the character of the soil, but on good, strong limestone land this may be taken as about the average. To grow wheat every year in crops of 15 bushels per acre, would impoverish the soil just as much as to summer-fallow and get 30 bushels of wheat every other year. It is the same thing in either case. But in summer-fallowing, we clean the land, and the *profits* from a crop of 30 bushels per acre every other year, are much more than from two crops of 15 bushels every year. You know that Mr. Lawes has a field of about thirteen acres that he sows with wheat every year. On the plot that receives no manure of any kind, the crop, for twenty years, averaged 16¼ bushels per acre. It is plowed twice every year, and the wheat is hand-hoed in the spring to keep it clean. A few years ago, in a field adjoining this experimental wheat field, and that is of the same character of land, he made the following experiment. The land, after wheat, was fallowed, and then sown to wheat; then fallowed the next year, and again sown to wheat, and the next year it was sown to wheat after wheat. The following is the result compared with the yield of the continuously unmanured plot in the experimental field that is sown to wheat every year:

1. YEAR—No. 1—Fallow						No crop.
No. 2—Wheat after wheat	15	bushels	3½	pecks	per	acre.
2. YEAR—No. 1—Wheat after fallow	37	"	—	"		"
No. 2—Wheat after wheat	13	"	3¼	"		"
3. YEAR—No. 1—Fallow after wheat						No crop.
No. 2—Wheat after wheat	15	bushels	3¼	pecks	per	acre.
4. YEAR—No. 1—Wheat after fallow	42	"	—	"		"
No. 2—Wheat after wheat	21	"	0¼	"		"
5. YEAR—No. 1—Wheat after wheat	17	"	1½	"		"
No. 2—Wheat after wheat	17	"	—			"

Taking the first four years, we have a total yield from the plot sown every year of 66 bushels 2¼ pecks, and from the two crops alternately fallowed, a total yield of 79 bushels. The next year, when wheat was sown after wheat on the land previously fallowed, the yield was almost identical with the yield from the plot that has grown wheat after wheat for so many years.

So far, these results do not indicate any exhaustion from the practice of fallowing. On the other hand, they tend to show that we can get *more* wheat by sowing it every other year, than by cropping it every year in succession. The reason for this may be found in the fact that in a fallow the land is more frequently exposed to the atmosphere by repeated plowings and harrowings; and it should be borne in mind that the effect of stirring the land is not necessarily in proportion to the total amount of stirring, but is according to the number of times that fresh particles of soil are exposed to the atmosphere. Two plowings and two harrowings in one week, will not do as much good as two plowings and two harrowings, at different times in the course of three or four months. It is for this reason that I object, theoretically, to sowing wheat after barley. We often plow the barley stubble twice, and spend considerable labor in getting the land into good condition; but it is generally all done in the course of ten days or two weeks. We do not get any adequate benefit for this labor. We can kill weeds readily at this season, (August), but the stirring of the soil does not develope the latent plant-food to the extent it would if the work was not necessarily done in such a limited period. I say *theoretically*, for in point of fact I *do* sow wheat after barley. I do so because it is very convenient, and because it is more immediately profitable. I am satisfied, however, that *in the end* it would be more profitable to seed down the barley with clover.

We *must* raise larger crops; and to do this we must raise them less frequently. This is the key-note of the coming improved system of American agriculture, in all sections where good land is worth less than one hundred dollars per acre. In the neighborhood of large cities, and wherever land commands a high price, we must keep our farms in a high state of fertility by the purchase of manures or cattle foods. Those of us in the interior, where we can not buy manure, must raise fewer grain crops, and more clover. We must aim to raise 40 bushels of wheat, 50 bushels of barley, 80 bushels of oats, and 100 bushels of shelled corn, and 5 bushels of clover-seed per acre. That this can be done on good, well-drained land, from the unaided resources of the farm, I have no doubt. It may give us no more grain to sell than at present, but it will enable us to produce much more mutton, wool, beef, cheese, butter, and pork, than at present.

"But, then, will there be a demand for the meat, wool, etc.?" The present indications are highly favorable. But we must aim to raise *good* meat. The low-priced beef and mutton sold in our markets are as unprofitable to the consumer as they are to the producer. We must feed higher, and to do this to advantage we must have improved stock. There is no profit in farming without good tillage, larger crops, improved stock, and higher feeding. The details will be modified by circumstances, but the principles are the same wherever agri-*culture* is practised.

CHAPTER IX.

HOW TO RESTORE A WORN-OUT FARM.

I have never yet seen a "worn-out" or "exhausted farm." I know many farms that are "run down." I bought just such a farm a dozen or more years ago, and I have been trying hard, ever since, to bring it up to a profitable standard of productiveness—and am still trying, and expect to have to keep on trying so long as I keep on farming. The truth is, there never was a farm so rich, that the farmer did not wish it was richer.

I have succeeded in making the larger part of my farm much more productive than it ever was before, since it was cleared from the original forest. But it is far from being as rich as I want it. The truth is, God sent us into this world to work, and He has given us plenty to do, if we will only do it. At any rate, this is true of farming. He has not given us land ready to our hand. The man who first cleared up my farm, had no easy task. He fairly earned all the good crops he ever got from it. I have never begrudged him one particle of the "natural manure" he took out of the land, in the form of wheat, corn, oats, and hay. On the dry, sandy knolls, he probably got out a good portion of this natural manure, but on the wetter and heavier portions of the farm, he probably did not get out one-hundredth part of the natural manure which the land contained.

Now, when such a farm came into my possession, what was I to do with it?

"Tell us what you did," said the Doctor, "and then, perhaps, we can tell you what you ought to have done, and what you ought to have left undone."

"I made many mistakes."

"Amen," said the Deacon; "I am glad to hear you acknowledge it."

"Well," said the Doctor, "it is better to make mistakes in trying to do something, than to hug our self-esteem, and fold our hands in indolence. It has been said that critics are men who have failed in their undertakings. But I rather think the most disagreeable, and self-satisfied critics, are men who have never done anything, or tried to do anything, themselves."

The Deacon, who, though something of an old fogy, is a good deal of a man, and possessed of good common sense, and much experience, took these remarks kindly. "Well," said he to me, "I must say that your farm has certainly improved, but you did things so differently from what we expected, that we could not see what you were driving at."

"I can tell you what I have been aiming at all along. 1st. To drain the wet portions of the arable land. 2d. To kill weeds, and make the soil mellow and clean. 3d. To make more manure."

"You have also bought some bone-dust, superphosphate, and other artificial manures."

"True; and if I had had more money I would have bought more manure. It would have paid well. I could have made my land as rich as it is now in half the time."

I had to depend principally on the natural resources of the land. I got out of the soil all I could, and kept as much of it as possible on the farm. One of the mistakes I made was, in breaking up too much land, and putting in too much wheat, barley, oats, peas, and corn. It would have been better for my pocket, though possibly not so good for the farm, if I had left more of the land in grass, and also, if I had summer-fallowed more, and sown less barley and oats, and planted less corn.

"I do not see how plowing up the grass land," said the Deacon, "could possibly be any better for the farm. You agricultural writers are always telling us that we plow too much land, and do not raise grass and clover enough."

"What I meant by saying that it would have been better for my pocket, though possibly not so good for the farm, if I had not plowed so much land, may need explanation. The land had been only half cultivated, and was very foul. The grass and clover fields did not give more than half a crop of hay, and the hay was poor in quality, and much of it half thistles, and other weeds. I plowed this land, planted it to corn, and cultivated it thoroughly. But the labor of keeping the corn clean was costly, and absorbed a very large slice of the profits. *But* the corn yielded a far larger produce per acre than I should have got had the land lain in grass. And as all this produce was consumed on the farm, we made more manure than if we had plowed less land."

I have great faith in the benefits of thorough tillage—or, in other words, of breaking up, pulverizing, and exposing the soil to the decomposing action of the atmosphere. I look upon a good, strong soil as a kind of storehouse of plant-food. But it is not an easy matter to render this plant-food soluble. If it were any less soluble than it is, it would have all leached out of the land centuries ago. Turning over, and fining a manure-heap, if other conditions are favorable, cause rapid fermentation with the formation of carbonate of ammonia, and other soluble salts. Many of our soils, to the depth of eight or ten inches, contain enough nitrogenous matter in an acre to produce two or three thousand pounds of ammonia. By stirring the soil, and exposing it to the atmosphere, a small portion of this nitrogen becomes annually available, and is taken up by the growing crops. And it is so with the other eleme ts of plant-food. Stirring the soil, then, is the basis of agriculture. It has been said that we must return to the soil as much plant-food as we take from it. If this were true, nothing could be sold from the farm. What we should aim to do, is to develop as much as possible of the plant-food that lies latent in the soil, and not to sell in the form of crops, cheese, wool, or animals, any more of this plant-food than we annually develop from the soil. In this way the "condition" of the soil would remain the same. If we sell *less* than we develop, the condition of the soil will improve.

By "condition," I mean the amount of *available* plant-food in the soil. Nearly all our farms are poorer in plant-food to-day than when first cleared of the original forest, or than they were ten, fifteen, or twenty years later. In other words, the plants and animals that have been sold from the farm, have carried off a considerable amount of plant-food. We have taken far more nitrogen, phosphoric acid, potash, etc., out of the soil, than we have returned to it in the shape of manure. Consequently, the soil must contain less and less of plant-food every year. And yet, while this is a self-evident fact, it is, nevertheless, true that many of these self-same farms are more productive now than when first cleared, or at any rate more productive than they were twenty-five or thirty years ago.

Sometime ago, the Deacon and I visited the farm of Mr. Dewey, of Monroe Co., N. Y. He is a good farmer. He does not practice "high farming" in the sense in which I use that term. His is a good example of what I term slow farming. He raises large crops, but comparatively few of them. On his farm of 300 acres, he raises 40 acres of wheat, 17 acres of Indian corn, and 23 acres of oats, barley, potatoes, roots, etc. In other words, he has 80 acres in crops, and 220 acres in grass—not permanent grass. He lets it lie in grass five, six, seven, or eight years, as he deems best, and then breaks it up, and plants it to corn. The land he intends to plant to corn next year, has been in grass for seven years. He will put pretty much all his manure on this land. After corn, it will be sown to oats, or barley; then sown to wheat, and seeded down again. It will then lie in grass three, four, five, six, or seven years, until he needs it again for corn, etc. This is "slow farming," but it is also good farming—that is to say, it gives large yields per acre, and a good return for the labor expended.

The soil of this farm is richer to-day in *available* plant-food than when first cleared. It produces larger crops per acre.

Mr. D. called our attention to a fact that establishes this point. An old fence that had occupied the ground for many years was removed some years since, and the two fields thrown into one. Every time this field is in crops, it is easy to see where the old fence was, by the short straw and poor growth on this strip, as compared with the land on each side which had been cultivated for years.

This is precisely the result that I should have expected. If Mr. D. was a poor farmer—if he cropped his land frequently, did not more than half-cultivate it, sold everything he raised, and drew back no manure—I think the old fence-strip would have given the best crops.

The strip of land on which the old fence stood in Mr. Dewey's field, contained *more* plant-food than the soil on either side of it. But it was not available. It was not developed. It was latent, inert, insoluble, crude, and undecomposed. It was so much dead capital. The land on either side which had been cultivated for years, produced better crops. Why? Simply because the stirring of the soil had developed *more* plant-food than had been removed by the crops. If the stirring of the soil developed 100 lbs. of plant-food a year, and only 75 lbs. were carried off in the crops—25 lbs. being left on the land in the form of roots, stubble, etc.—the land, at the expiration of 40 years, would contain, provided none of it was lost, 1,000 lbs. more *available* plant-food than the uncultivated strip. On the other hand, the latter would contain 3,000 lbs. more actual plant-food per acre than the land which had been cultivated—but it is in an unavailable condition. It is dead capital.

I do not know that I make myself understood, though I would like to do sc, because I am sure there is no point in scientific farming of greater importance. Mr. Geddes calls grass the "pivotal crop" of American agriculture. He deserves our thanks for the word and the idea connected with it. But I am inclined to think the *pivot* on which our agriculture stands and rotates, lies deeper than this. The grass crop creates nothing—developes nothing. The untilled and unmanured grass lands of Herkimer County, in this State, are no richer to-day than they were 50 years ago. The pastures of Cheshire, England, except those that have been top-dressed with bones, or other manures, are no more productive than they were centuries back. Grass alone will not make rich land. It is a good "savings bank." It gathers up and saves plant-food from running to waste. It pays a good interest, and is a capital institution. But the real source of fertility must be looked for *in the stores of plant-food lying dormant in the soil.* Tillage, underdraining, and thorough cultivation, are the means by which we develop and render this plant-food available. Grass, clover, peas, or any other crop consumed on the farm, merely affords us the means of saving this plant-food and making it pay a good interest.

CHAPTER X.

HOW TO MAKE MANURE.

If we have the necessary materials, it is not a difficult matter to make manure; in fact, the manure will make itself. We sometimes need to hasten the process, and to see that none of the fertilizing matter runs to waste. This is about all that we can do. We cannot create an atom of plant-food. It is ready formed to our hands; but we must know where to look for it, and how to get it in the easiest, cheapest, and best way, and how to save and use it. The science of manure-making is a profound study. It is intimately connected with nearly every branch of agriculture.

If weeds grow and decay on the land, they make manure. If we grow a crop of buckwheat, or spurry, or mustard, or rape, or clover, and mow it, and let it lie on the land, it makes manure; or if we plow it under, it forms manure; or if, after it is mown, we rake up the green crop, and put it into a heap, it will ferment, heat will be produced by the slow combustion of a portion of the carbonaceous and nitrogenous matter, and the result will be a mass of material, which we should all recognize as "manure." If, instead of putting the crop into a heap and letting it ferment, we feed it to animals, the digestible carbonaceous and nitrogenous matter will be consumed to produce animal heat and to sustain the vital functions, and the refuse, or the solid and liquid droppings of the animals, will be manure.

If the crop rots on the ground, nothing is added to it. If it ferments, and gives out heat, in a heap, nothing is added to it. If it is passed through an animal, and produces heat, nothing is added to it.

I have heard people say a farmer could not make manure unless he kept animals. We might with as much truth say a farmer cannot make ashes unless he keeps stoves; and it would be just as sensible to take a lot of stoves into the woods to make ashes, as it is to keep a lot of animals merely to make manure. You can make the ashes by throwing the wood into a pile, and burning it; and you can make the manure by throwing the material out of which the manure is to be made into a pile, and letting it ferment. On a farm where neither food nor manure of any kind is purchased, the only way to make manure is to *get it out of the land.*

"From the land and from the atmosphere," remarked the Doctor. "Plants get a large portion of the material of which they are composed from the atmosphere."

"Yes," I replied, "but it is principally carbonaceous matter, which is of little or no value as manure. A small amount of ammonia and nitric acid are also brought to the soil by rains and dews, and a freshly-stirred soil may also sometimes absorb more or less ammonia from the atmosphere; but while this is true, so far as making manure is concerned, we must look to the plant-food existing in the soil itself.

"Take such a farm as Mr. Dewey's, that we have already referred to. No manure or food has been purchased; or at any rate, not one-tenth as much as has been sold, and yet the farm is more productive to-day than when it was first cleared of the forest. He has developed the manure from the stores of latent plant-food previously existing in the soil; and this is the way farmers generally make manure."

CHAPTER XI.

THE VALUE OF MANURE DEPENDS ON THE FOOD—NOT ON THE ANIMAL.

"If," said I, "you should put a ton of cut straw in a heap, wet it, and let it rot down into manure; and should place in another heap a ton of cut corn-fodder, and in another heap a ton of cut clover-hay, wet them, and let them also rot down into manure; and in another heap a ton of pulped-turnips, and in another heap a ton of corn-meal, and in another heap a ton of bran, and in another a ton of malt-sprouts, and let them be mixed with water, and so treated that they will ferment without loss of ammonia or other valuable plant-food, I think no one will say that all these different heaps of manure will have the same value. And if not, why not?"

"Because," said Charley, "the ton of straw does not contain as much valuable plant-food as the ton of corn-fodder, nor the ton of corn-fodder as much as the ton of clover-hay."

"Now then," said I, "instead of putting a ton of straw in one heap to rot, and a ton of corn-fodder in another heap, and a ton of clover in another heap, we feed the ton of straw to a cow, and the ton of corn-fodder to another cow, and the ton of clover to another cow, and save *all* the solid and liquid excrements, will the manure made from the ton of straw be worth as much as the manure made from the ton of corn-fodder or clover-hay?"

"No," said Charley.—"Certainly not," said the Doctor.—"I am not so sure about it," said the Deacon; "I think you will get more manure from the corn-fodder than from the straw or clover-hay."

"We are not talking about bulk," said the Doctor, "but value." "Suppose, Deacon," said he, "you were to shut up a lot of your Brahma hens, and feed them a ton of corn-meal, and should also feed a ton of corn-meal made into slops to a lot of pigs, and should save *all* the liquid and solid excrements from the pigs, and all the manure from the hens, which would be worth the most?"—"The hen-manure, of course," said the Deacon, who has great faith in this kind of "guano," as he calls it.

"And yet," said the Doctor, "you would probably not get more than half a ton of manure from the hens, while the liquid and solid excrements from the pigs, if the corn-meal was made into a thin slop, would weigh two or three tons."

"More, too," said the Deacon, "the way you feed your store pigs."

"Very well; and yet you say that the half ton of hen-manure made from a ton of corn is worth more than the two or three tons of pig-manure made from a ton of corn. You do not seem to think, after all, that mere bulk or weight adds anything to the value of the manure. Why then should you say that the manure from a ton of corn-fodder is worth more than from a ton of straw, because it is more bulky?"

"You, yourself," said the Deacon, "also say the manure from the ton of corn-fodder is worth more than from the ton of straw."—"True," said I "but *not* because it is more bulky. It is worth more because the ton of corn-fodder contains a greater quantity of valuable plant-food than the ton of straw. The clover is still richer in this valuable plant-food, and the manure is much more valuable; in fact, the manure from the ton of clover is worth as much as the manure from the ton of straw and the ton of corn-fodder together."

"I would like to see you prove that," said the Deacon, "for if it is true, I will sell no more clover-hay. I can't get as much for clover-hay in the market as I can for rye-straw."

"I will not attempt to *prove* it at present," said the Doctor; "but the evidence is so strong and so conclusive that no rational man, who will study the subject, can fail to be thoroughly convinced of its truth."

"The value of manure," said I, "does not depend on the quantity of water which it contains, or on the quantity of sand, or silica, or on the amount of woody fibre or carbonaceous matter. These things add little or nothing to its fertilizing value, except in rare cases; and the sulphuric acid and lime are worth no more than the same quantity of sulphate of lime or gypsum, and the chlorine and soda are probably worth no more than so much common salt. The real chemical value of the manure, other things being equal, is in proportion to the nitrogen, phosphoric acid, and potash, that the manure contains.

"And the quantity of nitrogen, phosphoric acid, and potash found in the manure is determined, other things being equal, by the quantity of the nitrogen, phosphoric acid, and potash contained in the food consumed by the animals making the manure."

CHAPTER XII.

FOODS WHICH MAKE RICH MANURE.

The amount of nitrogen, phosphoric acid, and potash, contained in different foods, has been accurately determined by many able and reliable chemists.

The following table was prepared by Dr. J. B. Lawes, of Rothamsted, England, and was first published in this country in the "Genesee Farmer," for May, 1860. Since then, it has been repeatedly published in nearly all the leading agricultural journals of the world, and has given rise to much discussion. The following is the table, with some recent additions:

	PER CENT.					
	Total dry matter.	*Total mineral matter (ash).*	*Phosphoric acid reckoned as phosphate of lime*	*Potash.*	*Nitrogen.*	*Value of manure in dollars and cents from 1 ton (2,000 lbs.) of food*
1. Linseed cake	88.0	7.00	4.92	1.65	4.75	19.72
2. Cotton-seed cake *	89.0	8.00	7.00	3.12	6.50	27.86
3. Rape-cake	89.0	8.00	5.75	1.76	5.00	21.01
4. Linseed	90.0	4.00	3 38	1.37	3.80	15.65
5. Beans	84.0	3.00	2.20	1.27	4.00	15.75
6. Peas	84.5	2.40	1.84	0.96	3.40	13.38
7. Tares	84.0	2.00	1.63	0.66	4.20	16.75
8. Lentils	88.0	3.00	1.89	0.96	4.30	16.51
9. Malt-dust	94.0	8.50	5.23	2.12	4.20	18.21
10. Locust beans	85.0	1.75	...	....	1.25	4.81
11. Indian-meal	88.0	1.30	1.13	0.35	1.80	6.65
12. Wheat	85.0	1.70	1.87	0.50	1.80	7.08
13. Barley	84.0	2.20	1.35	0.55	1.65	6.32
14. Malt	95.0	2.60	1.60	0.65	1.70	6.65
15. Oats	86.0	2.85	1.17	0.50	2.00	7.70
16. Fine pollard †	86.0	5.60	6.44	1.46	2.60	13.53
17. Coarse pollard ‡	86.0	6.20	7.52	1.49	2.58	14.36
18. Wheat-bran	86.0	6.60	7.95	1.45	2.55	14.59
19. Clover-hay	84.0	7.50	1.25	1.30	2.50	9.64
20. Meadow-hay	84.0	6.00	0.88	1.50	1.50	6.43
21. Bean-straw	82.5	5.55	0.90	1.11	0.90	3.87
22. Pea-straw	82.0	5.95	0.85	0.89	....	3.74
23. Wheat-straw	84.0	5.00	0.55	0.65	0.60	2.68
24. Barley-straw	85.0	4 50	0.37	0.63	0.50	2.25
25. Oat-straw	83.0	5.50	0.48	0.93	0.60	2.90
26. Mangel-wurzel	12.5	1.00	0.09	0.25	0.25	1.07
27. Swedish turnips	11.0	.68	0.13	0.18	0.22	.91
28. Common turnips	8.0	.68	0.11	0.29	0.18	.86
29. Potatoes	24.0	1.00	0.32	0.43	0.35	1.50
30. Carrots	13.5	.70	0.13	0.23	0.20	.80
31. Parsnips	15.0	1.00	0.42	0.36	0.22	1.14

* The manure from a ton of undecorticated cotton-seed cake is worth $15.74; that from a ton of cotton-seed, after being ground and sifted, is worth $13.25. The grinding and sifting, in Mr. Lawes' experiments, removed about 8 per cent of husk and cotton. Cotton-seed, so treated, proved to be a very rich and economical food. † Middlings, Canielle. ‡ Shipstuff.

Of all vegetable substances used for food, it will be seen that decorticated cotton-seed cake is the richest in nitrogen, phosphoric acid, and potash, and consequently makes the richest and most valuable manure. According to Mr. Lawes' estimate, the manure from a ton of decorticated cotton-seed cake is worth $27.86 in gold.

Rape-cake comes next. Twenty-five to thirty years ago, rape-cake, ground as fine as corn-meal, was used quite extensively on many of the light-land farms of England as a manure for turnips, and not unfrequently as a manure for wheat. Mr. Lawes used it for many years in his experiments on turnips and on wheat.

Of late years, however, it has been fed to sheep and cattle. In other words, it has been used, not as formerly, for manure alone, but for food first, and manure afterwards. The oil and other carbonaceous matter which the cake contains is of little value for manure, while it is of great value as food. The animals take out this carbonaceous matter, and leave nearly all the nitrogen, phosphoric acid, and potash in the manure. Farmers who had found it profitable to use on wheat and turnips for manure alone, found it still more profitable to use it first for food, and then for manure afterwards. Mr. Lawes, it will be seen, estimates the manure produced from the consumption of a ton of rape-cake at $21.01.

Linseed-oil cake comes next. Pure linseed-cake is exceedingly valuable, both for food and manure. It is a favorite food with all cattle and sheep breeders and feeders. It has a wonderful effect in improving the appearance of cattle and sheep. An English farmer thinks he cannot get along without "cake" for his calves, lambs, cattle, and sheep. In this country, it is not so extensively used, except by the breeders of improved stock. It is so popular in England that the price is fully up to its intrinsic value, and not unfrequently other foods, in proportion to the nutritive and manurial value, can be bought cheaper. This fact shows the value of a good reputation. Linseed-cake, however, is often adulterated, and farmers need to be cautious who they deal with. When pure, it will be seen that the manure made by the consumption of a ton of linseed-cake is worth $19.72.

Malt-dust stands next on the list. This article is known by different names. In England, it is often called "malt-combs;" here it is known as "malt-*sprouts*," or "malt-*roots*." In making barley into malt, the barley is soaked in water, and afterwards kept in a warm room until it germinates, and throws out sprouts and roots. It is then dried, and before the malt is used, these dried sprouts and roots are sifted out, and are sold for cattle-food. They weigh from 22 to 25 lbs. per bushel of 40 quarts. They are frequently mixed at the breweries with the "grains," and are sold to milkmen at the same price—from 12 to 15 cents per bushel. Where their value is not known, they can, doubtless, be sometimes obtained at a mere nominal price. Milkmen, I believe, prefer the "grains" to the malt-dust. The latter, however, is a good food for sheep. It has one advantage over brewer's "grains." The latter contain 76 per cent of water, while the malt-dust contains only 6 per cent of water. We can afford, therefore, to transport malt-dust to a greater distance than the grains. We do not want to carry *water* many miles. There is another advantage: brewer's grains soon ferment, and become sour; while the malt-dust, being dry, will keep for any length of time. It will be seen that Mr. Lawes estimates the value of the manure left from the consumption of a ton of malt-dust at $18.21.

Tares or vetches, lentils, linseed or flaxseed, beans, wheat, bran, middlings, fine mill-feed, undecorticated cotton-seed cake, peas, and cotton-seed, stand next on the list. The value of these for manure ranging from $13.25 to $16.75 per ton.

Then comes clover-hay. Mr. Lawes estimates the value of the manure from the consumption of a ton of clover-hay at $9.64. This is from early cut clover-hay.

When clover is allowed to grow until it is nearly out of flower, the hay would not contain so much nitrogen, and would not be worth quite so much per ton for manure. When mixed with timothy or other grasses, or with weeds, it would not be so valuable. The above estimate is for the average quality of good pure English clover-hay. Our best farmers raise clover equally as good; but I have seen much clover-hay that certainly would not come up to this standard. Still, even our common clover-hay makes rich manure. In Wolff's Table, given in the appendix, it will be seen that clover-hay contains only 1.97 per cent of nitrogen and 5.7 per cent of ash. Mr. Lawes' clover contains more nitrogen and ash. This means richer land and a less mature condition of the crop.

The cereal grains, wheat, barley, oats, and Indian corn, stand next on the list, being worth from $6.32 to $7.70 per ton for manure.

"Meadow-hay," which in the table is estimated as worth $6.43 per ton for manure, is the hay from permanent meadows. It is a quite different article from the "English Meadow-hay" of New England. It is, in fact, the perfection of hay. The meadows are frequently top-dressed with composted manure or artificial fertilizers, and the hay is composed of a number of the best grasses, cut early and carefully cured. It will be noticed, however, that even this choice meadow-hay is not as valuable for manure as clover-hay.

English bean-straw is estimated as worth $3.87 per ton for manure. The English " horse bean," which is the kind here alluded to, has a very stiff, coarse long straw, and looks as though it was much inferior as fodder, to the straw of our ordinary white beans. See Wolff's table in the appendix.

Pea-straw is estimated at $3.74 per ton. When the peas are not allowed to grow until dead ripe, and when the straw is carefully cured, it makes capital food for sheep. Taking the grain and straw together, it will be seen that peas are an unusually valuable crop to grow for the purpose of making rich manure.

The straw of oats, wheat, and barley, is worth from $2.25 to $2.90 per ton. Barley straw being the poorest for manure, and oat straw the richest.

Potatoes are worth $1.50 per ton, or nearly 5 cents a bushel for manure.

The manurial value of roots varies from 80 cents a ton for carrots, to $1.07 for mangel-wurzel, and $1.14 for parsnips.

I am very anxious that there should be no misapprehension as to the meaning of these figures. I am sure they are well worth the careful study of every intelligent farmer. Mr. Lawes has been engaged in making experiments for over thirty years. There is no man more competent to speak with authority on such a subject. The figures showing the money value of the manure made from the different foods, are based on the amount of nitrogen, phosphoric acid, and potash, which they contain. Mr. Lawes has been buying and using artificial manures for many years, and is quite competent to form a correct conclusion as to the cheapest sources of obtaining nitrogen, phosphoric acid, and potash. He has certainly not overestimated their *cost*. They can not be bought at lower rates, either in England or America. But of course it does not follow from this that these manures are worth to the farmer the price charged for them; that is a matter depending on many conditions. All that can be said is, that if you are going to buy commercial manures, you will have to pay at least as much for the nitrogen, phosphoric acid, and potash, as the price fixed upon by Mr. Lawes. And you should recollect that there are other ingredients in the manure obtained from the food of animals, which are not estimated as of any value in the table. For instance, there is a large amount of carbonaceous matter in the manure of animals, which, for some crops, is not without value, but which is not here taken into account.

Viewed from a farmer's stand-point, the table of money values must be taken only in a comparative sense. It is not claimed that the manure from a ton of wheat-straw is worth $2.68. This may, or may not, be the case. But *if* the manure from a ton of wheat-straw is worth $2.68, *then* the manure from a ton of pea-straw is worth $3.74, and the manure from a ton of corn-meal is worth $6.65, and the manure from a ton of clover-hay is worth $9.64, and the manure from a ton of wheat-bran is worth $14.59. *If* the manure from a ton of corn meal is *not* worth $6.65, then the manure from a ton of bran is not worth $14.59. If the manure from the ton of corn is worth *more* than $6.65, then the manure from a ton of bran is worth *more* than $14.59. There need be no doubt on this point.

Settle in your own mind what the manure from a ton of any one of the foods mentioned is worth on your farm, and you can easily calculate what the manure is worth from all the others. If you say that the manure from a ton of wheat-straw is worth $1.34, then the manure from a ton of Indian corn is worth $3.33, and the manure from a ton of bran is worth $7.30, and the manure from a ton of clover-hay is worth $4.82.

In this section, however, few good farmers are willing to sell straw, though they can get from $8.00 to $10.00 per ton for it. They think it must be consumed on the farm, or used for bedding, or their land will run down. I do not say they are wrong, but I do say, that if a ton of straw is worth $2.68 for manure alone, then a ton of clover-hay is worth $9.64 for manure alone. This may be accepted as a general truth, and one which a farmer can act upon. And so, too, in regard to the value of corn-meal, bran, and all the other articles given in the table.

There is another point of great importance which should be mentioned in this connection. The nitrogen in the better class of foods is worth more for manure than the nitrogen in straw, corn-stalks, and other coarse fodder. Nearly all the nitrogen in grain, and other rich foods, is digested by the animals, and is voided in solution in the urine. In other words, the nitrogen in the manure is in an active and available condition. On the other hand, only about half the nitrogen in the coarse fodders and straw is digestible. The other half passes off in a crude and comparatively unavailable condition, in the solid excrement. In estimating the value of the manure from a ton of food, these facts should be remembered.

I have said that if the manure from a ton of straw is worth $2.68, the manure from a ton of corn is worth $6.65; but I will not reverse the proposition, and say that if the manure from a ton of corn is worth $6.65, the manure from a ton of straw is worth $2.68. The manure from the grain is nearly all in an available condition, while that from the straw is not. A pound of nitrogen in rich manure is worth more than a pound of nitrogen in poor manure. This is another reason why we should try to make rich manure.

CHAPTER XIII.

HORSE MANURE AND FARM-YARD MANURE.

The manure from horses is generally considered richer and better than that from cows. This is not always the case, though it is probably so as a rule. There are three principal reasons for this. 1st. The horse is usually fed more grain and hay than the cow. In other words, the food of the horse is usually richer in the valuable elements of plant-food than the ordinary food of the cow. 2d. The milk of the cow abstracts considerable nitrogen, phosphoric acid, etc., from the food, and to this extent there is less of these valuable substances in the excrements. 3d. The excrements of the cow contain much more water than those of the horse. And consequently a ton of cow-dung, other things being equal, would not contain as much actual manure as a ton of horse-dung.

Boussingault, who is eminently trustworthy, gives us the following interesting facts:

A horse consumed in 24 hours, 20 lbs. of hay, 6 lbs. of oats, and 43 lbs. of water, and voided during the same period, 3 lbs. 7 ozs. of urine, and 38 lbs. 2 ozs. of solid excrements.

The solid excrements contained 23½ lbs. of water, and the urine 2 lbs. 6 ozs. of water.

According to this, a horse, eating 20 lbs. of hay, and 6 lbs. of oats, per day, voids in a year nearly seven tons of solid excrements, and 1,255 lbs. of urine.

It would seem that there must have been some mistake in collecting the urine, or what was probably the case, that some of it must have been absorbed by the dung; for 3½ pints of urine per day is certainly much less than is usually voided by a horse.

Stockard gives the amount of urine voided by a horse in a year at 3,000 lbs.; a cow, 8,000 lbs.; sheep, 380 lbs.; pig, 1,200 lbs.

Dr. Vœlcker, at the Royal Agricultural College, at Cirencester, England, made some valuable investigations in regard to the composition of farm-yard manure, and the changes which take place during fermentation.

The manure was composed of horse, cow, and pig-dung, mixed with the straw used for bedding in the stalls, pig-pens, sheds, etc.

On the 3d of November, 1854, a sample of what Dr. Vœlcker calls "Fresh Long Dung," was taken from the "manure-pit" for analysis. It had lain in the pit or heap about 14 days.

The following is the result of the analysis:

FRESH FARM-YARD MANURE.

HALF A TON, OR 1,000 LBS.

Water	661.7 lbs.
Organic matter	282.4 "
Ash	55.9 "
	1,000.0 lbs.
Nitrogen	6.43 "

"Before you go any farther," said the Deacon, "let me understand what these figures mean? Do you mean that a ton of manure contains only 12¾ lbs. of nitrogen, and 111 lbs. of ash, and that all the rest is carbonaceous matter and water, of little or no value"?—"That is it precisely, Deacon," said I, "and furthermore, a large part of the ash has very little fertilizing value, as will be seen from the following:

DETAILED COMPOSITION OF THE ASH OF FRESH BARN-YARD MANURE.

Soluble silica	21.59
Insoluble silicious matter (sand)	10.04
Phosphate of lime	5.35
Oxide of iron, alumina, with phosphate	8.47
Containing phospheric acid	3.18
Lime	21.31
Magnesia	2.76
Potash	12.04
Soda	1.30
Chloride of sodium	0.54
Sulphuric acid	1.49
Carbonic acid and loss	15.11
	100.00

Nitrogen, phosphoric acid, and potash, are the most valuable ingredients in manure. It will be seen that a ton of fresh barn-yard manure, of probably good average quality, contains:

Nitrogen	12¾ lbs.
Phosphoric acid	6½ "
Potash	13⅓ "

I do not say that these are the only ingredients of any value in a ton of manure. Nearly all the other ingredients are indispensable to the growth of plants, and if we should use manures containing nothing but nitrogen, phosphoric acid, and potash, the time would come when the crops would fail, from lack of a sufficient quantity of, perhaps, magnesia, or lime, sulphuric acid, or soluble silica, or iron. But it is not necessary to make provision for such a contingency. It would be a very exceptional case. Farmers who depend mainly on barn-yard manure, or on plowing under green crops for keeping up the fertility of the land, may safely calculate that the value of the manure is in proportion to the amount of nitrogen, phosphoric acid, and potash, it contains.

We draw out a ton of fresh manure and spread it on the land, therefore, in order to furnish the growing crops with 12¾ lbs. of nitrogen, 6½ lbs. of phosphoric acid, and 13½ lbs. of potash. Less than 33 lbs. in all !

We cannot dispense with farm-yard manure. We can seldom buy nitrogen, phosphoric acid, and potash, as cheaply as we can get them in home-made manures. But we should clearly understand the fact that we draw out 2,000 lbs. of matter in order to get 33 lbs. of these fertilizing ingredients. We should *try to make richer manure.* A ton of manure containing 60 lbs. of nitrogen, phosphoric acid, and potash, costs no more to draw out and spread, than a ton containing only 30 lbs., and it would be worth nearly or quite double the money.

How to make richer manure we will not discuss at this time. It is a question of food. But it is worth while to enquire if we can not take such manure as we have, and reduce its weight and bulk without losing any of its nitrogen, phosphoric acid, and potash.

CHAPTER XIV.

FERMENTING MANURE.

Dr. Vœlcker placed 2,838 lbs. of fresh mixed manure in a heap Nov. 3, 1854, and the next spring, April 30, it weighed 2,026 lbs., a shrinkage in weight of 28.6 per cent. In other words 100 tons of such manure would be reduced to less than 71½ tons.

The heap was weighed again, August 23d, and contained 1,994 lbs. It was again weighed Nov. 15, and contained 1,974 lbs.

The following table shows the composition of the heap when first put up, and also at the three subsequent periods:

TABLE SHOWING COMPOSITION OF THE WHOLE HEAP; FRESH FARM-YARD MANURE (NO. I.) EXPOSED—EXPRESSED IN LBS.

	When put up Nov. 3, 1854.	*April* 30, 1855.	*Aug.* 23, 1855.	*Nov.* 15, 1855.
Weight of manure in lbs.	2,838	2,026	1,994	1,974
Amt. of water in the manure	1,877.9	1,336.1	1,505.3	1,466 5
Amt. of dry matter in the manure	960.1	689.9	488.7	507.5
Consisting of—				
Soluble organic matter	70.38	86.51	58.83	54.04
Soluble mineral matter	43.71	57.88	39.16	36.89
Insoluble organic matter	731.07	389.74	243.22	214.92
Insoluble mineral matter	114.94	155.77	147.49	201.65
	960.1	689.9	488.7	507.5
Containing nitrogen	4.22	6.07	3.76	3.65
Equal to ammonia	5.12	7.37	4.56	4.36
Containing nitrogen	14.01	12.07	9.38	9.38
Equal to ammonia	17.02	14.65	11.40	11.39
Total amount of nitrogen in manure.	18.23	18.14	13.14	13.03
Equal to ammonia	22.14	22.02	15.96	15.75
The manure contains ammonia in free state	.96	.15	.20	.11
The manure contains ammonia in form of salts, easily decomposed by quicklime	2.49	1.71	.75	.80
Total amount of organic matters	801.45	476.25	302.05	268.96
Total amount of mineral matters	158.15	213.65	186.65	238.54

"It will be remarked," says Dr. Vœlcker, "that in the first experimental period, the fermentation of the dung, as might have been expected, proceeded most rapidly, but that, notwithstanding, very little nitrogen was dissipated in the form of volatile ammonia; and that on the whole, the loss which the manure sustained was inconsiderable when compared with the enormous waste to which it was subject in the subsequent warmer and more rainy seasons of the year. Thus we find at the end of April very nearly the same amount of nitrogen which is contained in the fresh; whereas, at the end of August, 27.9 per cent of the total nitrogen, or nearly one-third of the nitrogen in the manure, has been wasted in one way or the other.

"It is worthy of observation," continues Dr. Vœlcker, "that, during a well-regulated fermentation of dung, the loss in intrinsically valuable constituents is inconsiderable, and that in such a preparatory process the *efficacy of the manure becomes greatly enhanced.* For certain purposes fresh dung can never take the place of well-rotted dung. * * The farmer will, therefore, always be compelled to submit a portion of home-made dung to fermentation, and will find satisfaction in knowing that this process, when well regulated, is not attended with any serious depreciation of the value of the manure. In the foregoing analyses he will find the direct proof that as long as heavy showers of rain are excluded from manure-heaps, or the manure is kept in water-proof pits, the most valuable fertilizing matters are preserved."

This experiment of Dr. Vœlcker proves conclusively that manure can be kept in a rapid state of fermentation for six months during winter, with little loss of nitrogen or other fertilizing matter.

During fermentation a portion of the insoluble matter of the dung becomes soluble, and if the manure is then kept in a heap exposed to rain, there is a great loss of fertilizing matter. This is precisely what we should expect. We ferment manure to make it more readily available as plant-food, and when we have attained our object, the manure should be applied to the land. We keep winter apples in the cellar until they get ripe. As soon as they are ripe, they should be eaten, or they will rapidly decay. This is well understood. And it should be equally well known that manure, after it has been fermenting in a heap for six months, cannot safely be kept for another six months exposed to the weather.

The following table shows the composition of 100 lbs. of the farm-yard manure, at different periods of the year :

COMPOSITION OF 100 LBS. OF FRESH FARM-YARD MANURE (NO. I.) EXPOSED IN NATURAL STATE, AT DIFFERENT PERIODS OF THE YEAR.

	When put up, Nov. 3, 1854.	*Feb.* 14, 1855.	*Apr.* 30, 1855.	*Aug.* 23, 1855.	*Nov.* 15, 1855.
Water...	66.17	69.83	65.95	75.49	74.29
Soluble organic matter	2.48	3.86	4.27	2.95	2.74
Soluble inorganic matter	1.54	2.97	2.86	1.97	1.87
Insoluble organic matter	25.76	18.44	19.23	12.20	10.89
Insoluble mineral matter	4.05	4.90	7.69	7.39	10.21
	100.00	100.00	100.00	100.00	100.00
Containing nitrogen	.149	.27	.30	.19	.18
Equal to ammonia	.181	.32	.36	.23	.21
Containing nitrogen	.494	.47	.59	.47	.47
Equal to ammonia	.599	.57	.71	.62	.57
Total amount of nitrogen	.643	.74	.89	.66	.65
Equal to ammonia	.780	.89	1.07	.85	.78
Ammonia in a free state	.034	.019	.008	.010	.006
Ammonia in form of salts easily decomposed by quicklime	.088	.064	.085	.038	.041
Total amt. of organic matter	28.24	22.30	23.50	15.15	13.63
Total amt. of mineral substances	5.59	7.87	10.55	9.36	12.08

It will be seen that two-thirds of the fresh manure is water. After fermenting in an exposed heap for six months, it still contains about the same *percentage* of water. When kept in the heap until August, the percentage of water is much greater. Of four tons of such manure, three tons are water.

Of *Nitrogen*, the most valuable ingredient of the manure, the fresh dung, contained 0.64 per cent; after fermenting six months, it contained 0.89 per cent. Six months later, it contained 0.65 per cent, or about the same amount as the fresh manure.

Of mineral matter, or ash, this fresh farm-yard manure contained 5.59 per cent; of which 1.54 was soluble in water, and 4.05 insoluble. After fermenting in the heap for six months, the manure contained 10.55 per cent of ash, of which 2.86 was soluble, and 7.69 insoluble. Six months later, the soluble ash had decreased to 1.97 per cent.

The following table shows the composition of the manure, at different periods, in the *dry state.* In other words, supposing all the water to be removed from the manure, its composition would be as follows:

COMPOSITION OF FRESH FARM-YARD MANURE (NO. I.) EXPOSED. CALCULATED DRY.

	When put up, Nov. 3, 1854.	*Feb.* 14, 1855.	*April* 30, 1855.	*Aug.* 23, 1855.	*Nov.* 15, 1855.
Soluble organic matter	7.33	12.79	12.54	12.04	10.65
Soluble inorganic matter	4.55	9.84	8.39	8.03	7.27
Insoluble organic matter	76.15	61.12	56.49	49.77	42.35
Insoluble mineral matter	11.97	16.25	22.58	30.16	39.73
	100.00	100.00	100.00	100.00	100.00
Containing nitrogen	.44	.91	.88	.77	.72
Equal to ammonia	.53	1.10	1.06	.93	.88
Containing nitrogen	1.46	1.55	1.75	1.92	1.85
Equal to ammonia	1.77	1.88	2.12	2.33	2.24
Total amount of nitrogen	1.90	2.46	2.63	2.69	2.57
Equal to ammonia	2.30	2.98	3.18	3.26	3.12
Ammonia in free state	.10	.062	.023	.041	.023
Ammonia in form of salts easily decomposed by quicklime	.26	.212	.249	.154	.159
Total amount of organic matter	83.48	73.91	69.03	61.81	53.00
Total amount of mineral substances	16.52	26.09	30.97	38.19	47.00

"A comparison of these different analyses," says Dr. Vœlcker, "points out clearly the changes which fresh farm-yard manure undergoes on keeping in a heap, exposed to the influence of the weather during a period of twelve months and twelve days.

"1. It will be perceived that the proportion of organic matter steadily diminishes from month to month, until the original percentage of organic matter in the dry manure, amounting to 83.48 per cent, becomes reduced to 53 per cent.

"2. On the other hand, the total percentage of mineral matter rises as steadily as that of the organic matter falls.

"3. It will be seen that the loss in organic matter affects the percentage of insoluble organic matters more than the percentage of soluble organic substances.

"4. The percentage of soluble organic matters, indeed, increased considerably during the first experimental period; it rose, namely, from 7.33 per cent to 12.79 per cent. Examined again on the 30th of April, very nearly the same percentage of soluble organic matter, as on February the 14th, was found. The August analysis shows but a slight decrease in the percentage of soluble organic matters, while there is a decrease of 2 per cent of soluble organic matters when the November analysis is compared with the February analysis.

"5. The soluble mineral matters in this manure rise or fall in the different experimental periods in the same order as the soluble organic matters. Thus, in February, 9.84 per cent of soluble mineral matters were found, whilst the manure contained only 4.55 per cent, when put up into a heap in November, 1854. Gradually, however, the proportion of soluble mineral matters again diminished, and became reduced to 7.27 per cent, on the examination of the manure in November, 1855.

"6. A similar regularity will be observed in the percentage of nitrogen contained in the soluble organic matters.

"In the insoluble organic matters, the percentage of nitrogen regularly increased from November, 1854, up to the 23d of August, notwithstanding the rapid diminution of the percentage of insoluble organic matter. For the last experimental period, the percentage of nitrogen in the insoluble matter is nearly the same as on August 23d.

"8. With respect to the total percentage of nitrogen in the fresh manure, examined at different periods of the year, it will be seen that the February manure contains about one-half per cent more of nitrogen than the manure in a perfectly fresh state. On the 30th of April, the percentage of nitrogen again slightly increased; on August 23d, it remained stationary, and had sunk but very little when last examined on the 15th of November, 1855.

"This series of analyses thus shows that fresh farm-yard manure rapidly becomes more soluble in water, but that this desirable change is realized at the expense of a large proportion of organic matters. It likewise proves, in an unmistakable manner, that there is no advantage in keeping farm-yard manure for too long a period; for, after February, neither the percentage of soluble organic, nor that of soluble mineral matter, has become greater, and the percentage of nitrogen in the manure of April and August is only a very little higher than in February."

"Before you go any further," said the Deacon, "answer me this question: Suppose I take five tons of farm-yard manure, and put it in a heap on the 3d of November, tell me, 1st, what that heap will contain when first made; 2d, what the heap will contain April 30th; and, 3d, what the heap will contain August 23d."

Here is the table:

CONTENTS OF A HEAP OF MANURE AT DIFFERENT PERIODS, EXPOSED TO RAIN, ETC.

	When put up, Nov. 3.	*April* 30.	*Aug.* 23.	*Nov.* 15.
Total weight of manure in heap......	10,000	7,138	7,025	6.954
Water in the heap of manure..	6,617	4,707	5.304	5,167
Total organic matter..................	2,824	1,678	1,064	947
Total inorganic matter................	559	753	657	840
Total nitrogen in heap................	64.3	63.9	46.3	46.0
Total soluble organic matter.........	248	305	207	190
Total insoluble organic matter.......	2,576	1,373	857	757
Soluble mineral matter...	154	204	138	130
Insoluble mineral matter.............	405	549	519	710
Nitrogen in soluble matter...........	14.9	21.4	13.2	12.9
Nitrogen in insoluble matter.........	49.4	42.5	33.1	33.1

The Deacon put on his spectacles and studied the above table carefully for some time. "That tells the whole story," said he, "you put five tons of fresh manure in a heap, it ferments and gets warm, and nearly one ton of water is driven off by the heat."

"Yes," said the Doctor, "you see that over half a ton (1,146 lbs.) of dry organic matter has been slowly burnt up in the heap; giving out as much heat as half a ton of coal burnt in a stove. But this is not all. The manure is cooked, and steamed, and softened by the process. The organic matter burnt up is of no value. There is little or no loss of nitrogen. The heap contained 64.3 lbs. of nitrogen when put up, and 63.9 lbs. after fermenting six months. And it is evident that the manure is in a much more active and available condition than if it had been applied to the land in the fresh state. There was 14.9 lbs. of nitrogen in a soluble condition in the fresh manure, and 21.4 lbs. in the fermented manure. And what is equally important, you will notice that there is 154 lbs. of soluble ash in the heap of fresh manure, and 204 lbs. in the heap of fermented manure. In other words, 50 lbs. of the insoluble mineral matter had, by the fermentation of the manure, been rendered soluble, and consequently immediately available as plant-food. This is a very important fact."

The Doctor is right. There is clearly a great advantage in fermenting manure, provided it is done in such a manner as to prevent loss. We have not only less manure to draw out and spread, but the plant-food which it contains, is more soluble and active.

The table we have given shows that there is little or no loss of valuable constituents, even when manure is fermented in the open air and exposed to ordinary rain and snows during an English winter. But it also shows that when the manure has been fermented for six months, and is then turned and left exposed to the rain of spring and summer, the loss is very considerable.

The five tons (10,000 lbs.,) of fresh manure placed in a heap on the 3d of November, are reduced to 7,138 lbs. by the 30th of April. Of this 4,707 lbs. is water. By the 23d of August, the heap is reduced to 7,025 lbs., of which 5,304 lbs. is water. There is nearly 600 lbs. more water in the heap in August than in April.

Of total nitrogen in the heap, there is 64.3 lbs. in the fresh manure, 63.9 lbs. in April, and only 46.3 lbs. in August. This is a great loss, and there is no compensating gain.

We have seen that, when five tons of manure is fermented for six months, in winter, the nitrogen in the soluble organic matter is increased from 14.9 lbs. to 21.4 lbs. This is a decided advantage. But when the manure is kept for another six months, this soluble nitrogen is decreased from 21.4 lbs. to 13.2 lbs. We lose over 8 lbs. of the most active and available nitrogen.

And the same remarks will apply to the valuable soluble mineral matter. In the five tons of fresh manure there is 154 lbs. of soluble mineral matter. By fermenting the heap six months, we get 204 lbs., but by keeping the manure six months longer, the soluble mineral matter is reduced to 138 lbs. We lose 66 lbs. of valuable soluble mineral matter.

By fermenting manure for six months in winter, we greatly improve its condition; by keeping it six months longer, we lose largely of the very best and most active parts of the manure.

CHAPTER XV.

KEEPING MANURE UNDER COVER.

Dr. Vœlcker, at the same time he made the experiments alluded to in the preceding chapter, placed another heap of manure *under cover*, in a shed. It was the same kind of manure, and was treated precisely as the other—the only difference being that one heap was exposed to the rain, and the other not. The following table gives the results of the weighings of the heap at different times, and also the percentage of loss:

MANURE FERMENTED UNDER COVER IN SHED.

TABLE SHOWING THE ACTUAL WEIGHINGS, AND PERCENTAGE OF LOSS IN WEIGHT, OF EXPERIMENTAL HEAP (NO. II.) FRESH FARM-YARD MANURE UNDER SHED, AT DIFFERENT PERIODS OF THE YEAR.

	Weight of Manure in Lbs.	*Loss in original weight in Lbs.*	*Per cent-age of Loss.*
Put up on the 3d of November, 1854..................	3,258		
Weighed on the 30th of April, 1855, or after a lapse of 6 months....	1,613	1,645	50.4
Weighed on the 23d of August, 1855, or after a lapse of 9 months and 20 days...........................	1,297	1,961	60.0
Weighed on the 15th of November, 1855, or after a lapse of 12 months and 12 days.....................	1,235	2,023	62.1

It will be seen that 100 tons of manure, kept in a heap under cover for six months, would be reduced to 49.6-10 tons. Whereas, when the same manure was fermented for the same length of time in the open air, the 100 tons was reduced to only 71.4-10 tons. The difference is due principally to the fact that the heap exposed contained more water, derived from rain and snow, than the heap kept under cover. This, of course, is what we should expect. Let us look at the results of Dr. Vœlcker's analyses:

TABLE SHOWING THE COMPOSITION OF EXPERIMENTAL HEAP (NO. II.) FRESH FARM-YARD MANURE UNDER SHED, IN NATURAL STATE AT DIFFERENT PERIODS OF THE YEAR.

	When put up, Nov. 3, 1854.	*Feb.* 14, 1855.	*Apr.* 30, 1855.	*Aug.* 23, 1855.	*Nov.* 15, 1855.
Water...	66.17	67.32	56.89	43.43	41.66
*Soluble organic matter	2.43	2.63	4.63	4.13	5.37
Soluble inorganic matter	1.54	2.12	3.38	3.05	4.43
†Insoluble organic matter	25 76	20.46	25.43	26.01	27.69
Insoluble mineral matter	4.05	7.47	9.67	23.38	20.85
	100.00	100.00	100.00	100.00	100.00
*Containing nitrogen	.149	.17	.27	.26	.42
Equal to ammonia	.181	.20	.32	.31	.51
†Containing nitrogen	.494	.58	.92	1.01	1.09
Equal to ammonia	.599	.70	1.11	1.23	1.31
Total amount of nitrogen	.643	.75	1.19	1.27	1.51
Equal to ammonia	.780	.90	1.43	1.54	1.82
Ammonia in free state	.034	.022	.055	.015	.019
Ammonia in form of salts easily decomposed by quicklime	.088	.054	.101	.103	.146
Total amount of organic matter	28.24	23.09	30.06	30.14	33.06
Total amount of mineral substance	5.59	9.59	13.05	26.43	25.23

TABLE SHOWING THE COMPOSITION OF EXPERIMENTAL HEAP (NO. II.) FRESH FARM-YARD MANURE UNDER SHED, CALCULATED DRY, AT DIFFERENT PERIODS OF THE YEAR.

	When put up, Nov. 3, 1854.	*Feb.* 14, 1855.	*Apr.* 30, 1855.	*Aug.* 23, 1855.	*Nov.* 15, 1855.
*Soluble organic matter	7.33	8.04	10.74	7.30	9.20
Soluble inorganic matter	4.55	6.48	7.84	5.39	7.59
†Insoluble organic matter	76.15	62.60	58.99	45.97	47.46
Insoluble mineral matter	11.97	22.88	22.43	41.34	35.75
	100.00	100.00	100.00	100.00	100.00
*Containing nitrogen	.44	.53	.63	.46	.72
Equal to ammonia	.53	.65	.76	.56	.88
†Containing nitrogen	1.46	1.77	2.14	1.78	1.88
Equal to ammonia	1.77	2.14	2.59	2.16	2 20
Total amount of nitrogen	1.90	2.30	2.77	2.24	2.60
Equal to ammonia	2.30	2.80	3.35	2.72	3.08
Ammonia in free state	.10	.067	.127	.026	.032
Ammonia in form of salts, easily decomposed by quicklime	.26	.165	.234	.182	.250
Total amount of organic matter	83.48	70.64	69.73	53.27	56.66
Total amount of mineral substance	16.52	29.36	30 27	46.73	43.34

The above analyses are of value to those who buy fresh and fermented manure. They can form some idea of what they are getting. If they buy a ton of fresh manure in November, they get 12¾ lbs. of nitrogen, and 30¾ lbs. of soluble mineral matter. If they buy a ton of the same manure that has been kept under cover until February, they get, nitrogen, 15 lbs.; soluble minerals, 42½ lbs. In April, they get, nitrogen, 23¾ lbs.; soluble minerals, 67½ lbs. In August, they get, nitrogen, 25½ lbs.; soluble minerals, 61 lbs. In November, when the manure is over one year old, they get, in a ton, nitrogen, 30¼ lbs.; soluble minerals, 88½ lbs.

When manure has not been exposed, it is clear that a purchaser can afford to pay considerably more for a ton of rotted manure than for a ton of fresh manure. But waiving this point for the present, let us see how the matter stands with the farmer who makes and uses the manure. What does he gain by keeping and fermenting the manure under cover?

The following table shows the weight and composition of the entire heap of manure, kept under cover, at different times:

TABLE SHOWING COMPOSITION OF ENTIRE EXPERIMENTAL HEAP (NO. II.) FRESH FARM-YARD MANURE, UNDER SHED.

	When put up, Nov. 3, 1854.	*April* 30, 1855.	*Aug.* 23, 1855.	*Nov.* 15, 1855.
	lbs.	lbs.	lbs.	lbs.
Weight of manure	3.258.	1,613.	1,297.	1,235.
Amount of water in the manure	2,156.	917.6	563.2	514.5
Amount of dry matter	1,102.	695.4	733.8	720.5
*Consisting of soluble organic matter	80.77	74.68	53.56	66.28
Soluble mineral matter	50.14	54.51	39.55	54.68
†Insoluble organic matter	839.17	410.24	337.32	341.97
Insoluble mineral matter	131.92	155.97	303.37	257.57
	1,102.	695.4	733.8	720.5
*Containing nitrogen	4.85	4.38	3.46	5.25
Equal to ammonia	5.83	5.33	4.20	6.37
†Containing nitrogen	16.08	14.88	13.08	13.54
Equal to ammonia	19.52	17.46	15.88	16.44
Total amount of nitrogen in manure	20.93	19.26	16.54	18.79
Equal to ammonia	25.40	22.79	20.08	22.81
The manure contains ammonia in free state	1.10	.88	.19	.23
The manure contains ammonia in form of salts, easily decomposed by quick-lime	2.86	1.62	1.33	1.80
Total amount of organic matter	919.94	484.92	390.88	408.25
Total amount of mineral matter	182.06	210.48	342.92	312.35

This is the table, as given by Dr. Vœlcker. For the sake of comparison, we will figure out what the changes would be in a heap of five tons (10,000 lbs.) of manure, when fermented under cover, precisely in the same way as we did with the heap fermented in the open air, exposed to the rain. The following is the table:

CONTENTS OF A HEAP OF MANURE AT DIFFERENT PERIODS. FERMENTED UNDER COVER.

	When put up, Nov. 3.	*April* 30.	*Aug.* 23.	*Nov.* 15.
	lbs.	lbs.	lbs.	lbs.
Total weight of manure in heap......	10,000	4,960	4,000	3,790
Water in the heap of manure........	6,617	2,822	1,737	1,579
Total organic matter..........	2,824	1,490	1,205	1,253
Total inorganic matter...	559	646	1,057	958
Total nitrogen in heap...............	64.3	59	50.8	57.2
Total soluble organic matter.........	248	230	165	203.5
Insoluble organic matter.............	2,576	1,260	1,040	1,049
Soluble mineral matter..........	154	167	122	168
Insoluble mineral matter.............	405	479	935	790
Nitrogen in soluble matter...........	14.9	13.4	10.4	15.9
Nitrogen in insoluble matter.........	49.4	45.6	40.4	41.3
Total dry matter in heap............	3.383	2,038	2,263	2,211

It will be seen that the heap of manure kept under cover contained, on the 30th of April, *less* soluble organic matter, *less* soluble mineral matter, *less* soluble nitrogenous matter, and *less* total nitrogen than the heap of manure exposed to the weather. This is precisely what I should have expected. The heap of manure in the shed probably fermented more rapidly than the heap out of doors, and there was not water enough in the manure to retain the carbonate of ammonia, or to favor the production of organic acids. *The heap was too dry.* If it could have received enough of the liquid from the stables to have kept it moderately moist, the result would have been very different.

We will postpone further consideration of this point at present, and look at the results of another of Dr. Vœlcker's interesting experiments.

Dr. Vœlcker wished to ascertain the effect of three common methods of managing manure:

1st. Keeping it in a *heap* in the open air in the barn-yard, or field.

2d. Keeping it in a *heap* under cover in a shed.

3d. Keeping it *spread out* over the barn-yard.

"You say these are common methods of managing manure," remarked the Deacon, "but I never knew any one in this country take the trouble to spread manure over the yard."

"Perhaps not," I replied, "but you have known a good many farmers who adopt this very method of keeping their manure. They do not spread it—but they let it lie spread out over the yards, just wherever it happens to be."

Let us see what the effect of this treatment is on the composition and value of the manure.

We have examined the effect of keeping manure in a heap in the open air, and also of keeping it in a heap under cover. Now let us see how these methods compare with the practice of leaving it exposed to the rains, spread out in the yard.

On the 3rd of November, 1854, Dr. Vœlcker weighed out 1,652 lbs. of manure similar to that used in the preceding experiments, and spread it out in the yard. It was weighed April 30, and again August 23, and November 15.

The following table gives the actual weight of the manure at the different periods, also the actual amount of the water, organic matter, ash, nitrogen, etc.:

TABLE SHOWING THE WEIGHT AND COMPOSITION OF ENTIRE MASS OF EXPERIMENTAL MANURE (NO. III.), FRESH FARM-YARD MANURE, SPREAD IN OPEN YARD AT DIFFERENT PERIODS OF THE YEAR. IN NATURAL STATE.

	When put up, Nov. 3, 1854.	*April* 30, 1855.	*Aug.* 23, 1855.	*Nov.* 15, 1855.
	lbs.	lbs.	lbs.	lbs.
Weight of manure	1,652.	1,429.	1,012.	950.
Amount of water in the manure	1,093.	1,143.	709.3	622.8
Amount of dry matter	559.	285.5	302.7	327.2
*Consisting of soluble organic matter	40.97	16.55	4.96	3.95
Soluble mineral matter	25,43	14.41	6.47	5.52
†Insoluble organic matter	425.67	163.79	106.81	94.45
Insoluble mineral matter	66.93	90.75	184.46	223.28
	559.00	285.50	302.70	327.20
*Containing nitrogen	3.28	1.19	.60	.32
Equal to ammonia	3.98	1.44	.73	.39
†Containing nitrogen	6.21	6.51	3.54	3.56
Equal to ammonia	7.54	7.90	4.29	4.25
Total amount of nitrogen in manure	9.49	7.70	4.14	3.88
Equal to ammonia	11.52	9.34	5.02	4.64
The manure contains ammonia in free state	.55	.14	.13	.0055
The manure contains ammonia in form of salts, easily decomposed by quick-lime	1.45	.62	.55	.28
Total amount of organic matter	466.64	180.34	111.77	98.40
Total amount of mineral matter	92.36	105.16	190.93	228.80

"One moment," said the Deacon. "These tables are a little confusing. The table you have just given shows the actual weight of the manure in the heap, and what it contained at different periods."—"Yes," said I, "and the table following shows what 100 lbs. of this manure, spread out in the yard, contained at the different dates mentioned. It shows how greatly manure deteriorates by being exposed to rain, spread out on the surface of the yard. The table merits careful study."

TABLE SHOWING COMPOSITION OF EXPERIMENTAL HEAP (NO. III.), FRESH FARM-YARD MANURE, SPREAD IN OPEN YARD, AT DIFFERENT PERIODS OF THE YEAR. IN NATURAL STATE.

	When put up, Nov. 3, 1854.	*April* 30, 1855.	*Aug.* 23, 1855.	*Nov.* 15, 1855.
Water	66.17	80.02	70.09	65.56
*Soluble organic matter	2.48	1.16	.49	.42
Soluble inorganic matter	1.54	1.01	.64	.57
†Insoluble organic matter	25.76	11.46	10.56	9.94
Insoluble mineral matter	4.05	6.35	18.22	23.51
	100.00	100.00	100.00	100.00
*Containing nitrogen	.149	.08	.06	.03
Equal to ammonia	.181	.09	.07	.036
†Containing nitrogen	.494	.45	.35	.36
Equal to ammonia	.599	.54	.42	.46
Total amount of nitrogen	.643	.55	.41	.39
Equal to ammonia	.780	.63	.49	.496
Ammonia in free state	.034	.010	.012	.0006
Ammonia in form of salts, easily decomposed by quicklime	.088	.045	.051	.030
Total amount of organic matter	28.24	12.62	11.05	10.36
Total amount of mineral substance	5.59	7.36	18.86	24.08

The following table shows the composition of the manure, calculated dry:

TABLE SHOWING COMPOSITION OF EXPERIMENTAL HEAP (NO. III.), FRESH FARM-YARD MANURE, SPREAD IN OPEN YARD, AT DIFFERENT PERIODS OF THE YEAR. CALCULATED DRY.

	When put up, Nov. 3, 1854.	*April* 30, 1855.	*Aug.* 23, 1855.	*Nov.* 15, 1855.
*Soluble organic matter	7.33	5.80	1.64	1.21
Soluble inorganic matter	4.55	5.05	2.14	1.69
†Insoluble organic matter	76.15	57.37	35.30	28.86
Insoluble mineral matter	11.97	31.78	60.92	68.24
	100.00	100.00	100.00	100.00
*Containing nitrogen	.44	.42	.20	.10
Equal to ammonia	.53	.51	.24	.12
†Containing nitrogen	1.46	2.28	1.17	1.09
Equal to ammonia	1.77	2.76	1.41	1.32
Total amount of nitrogen	1.90	2.70	1.37	1.19
Equal to ammonia	2.30	3.27	1.65	1.44
Ammonia in free state	.10	.05	.040	.0017
Ammonia in form of salts, easily decomposed by quicklime	.26	.225	.171	.087
Total amount of organic matter	83.48	63.17	36.94	30.07
Total amount of mineral substance	16.52	36.83	63.06	69.93

I have made out the following table, showing what would be the changes in a heap of 5 tons (10,000 lbs.) of manure, spread out in the yard, so that we can readily see the effect of this method of management as compared with the other two methods of keeping the manure in compact heaps, one exposed, the other under cover. The following is the table:

CONTENTS OF THE MASS OF MANURE, SPREAD OUT IN FARM-YARD, AND EXPOSED TO RAIN, ETC.

	When spread out, Nov. 3.	*April* 30.	*Aug.* 23.	*Nov.* 15.
	lbs.	lbs.	lbs.	lbs.
Total weight of manure..........	10,000	8,650	6,130	5,750
Water in the manure..............	6,617	6,922	4,297	3,771
Total organic matter..............	2,824	1,092	677	595
Total inorganic matter............	559	636	1,155	1,384
Total nitrogen in manure..........	64.3	45.9	25	22.4
Total soluble organic matter......	248	100	30	24
Insoluble organic matter..........	2,576	992	647	571
Soluble mineral matter	154	87	39	33
Insoluble mineral matter..........	405	549	1,116	1,351
Nitrogen in soluble matter........	14.9	6.9	3.6	1.7
Nitrogen in insoluble matter......	49.4	39	21.4	20.7

It is not necessary to make many remarks on this table. The facts speak for themselves. It will be seen that there is considerable loss even by letting the manure lie spread out until spring; but, serious as this loss is, it is small compared to the loss sustained by allowing the manure to lie exposed in the yard during the summer.

In the five tons of fresh manure, we have, November 3, 64.3 lbs. of nitrogen; April 30, we have 46 lbs.; August 23, only 25 lbs. This is a great loss of the most valuable constituent of the manure. Of soluble mineral matter, the next most valuable ingredient, we have in the five tons of fresh manure, November 3, 154 lbs.; April 30, 87 lbs.; and August 23, only 39 lbs. Of soluble nitrogen, the most active and valuable part of the manure, we have, November 3, nearly 15 lbs.; April 30, not quite 7 lbs.; August 23, 3½ lbs.; and November 15, not quite 1¾ lbs.

Dr. Vœlcker made still another experiment. He took 1,613 lbs. of *well-rotted* dung (mixed manure from horses, cows, and pigs,) and kept it in a heap, exposed to the weather, from December 5 to April 30, August 23, and November 15, weighing it and analyzing it at these different dates. I think it is not necessary to give the results in detail. From the 5th of December to the 30th of April, there was *no loss* of nitrogen in the heap, and comparatively little loss of soluble mineral matters; but from April 30 to August 23, there was considerable loss in both these valuable ingredients, which were washed out of the heap by rain.

Dr. Voelcker draws the following conclusions from his experiments:

"Having described at length my experiments with farm-yard manure," he says, "it may not be amiss to state briefly the more prominent and practically interesting points which have been developed in the course of this investigation. I would, therefore, observe:

"1. Perfectly fresh farm-yard manure contains but a small proportion of free ammonia.

"2. The nitrogen in fresh dung exists principally in the state of insoluble nitrogenized matters.

"3. The soluble organic and mineral constituents of dung are much more valuable fertilizers than the insoluble. Particular care, therefore, should be bestowed upon the preservation of the liquid excrements of animals, and for the same reason the manure should be kept in perfectly water-proof pits of sufficient capacity to render the setting up of dung-heaps in the corner of fields, as much as it is possible, unnecessary.

"4. Farm-yard manure, even in quite a fresh state, contains phosphate of lime, which is much more soluble than has hitherto been suspected.

"5. The urine of the horse, cow, and pig, does not contain any appreciable quantity of phosphate of lime, whilst the drainings of dung-heaps contain considerable quantities of this valuable fertilizer. The drainings of dung-heaps, partly for this reason, are more valuable than the urine of our domestic animals, and, therefore, ought to be prevented by all available means from running to waste.

"6. The most effectual means of preventing loss in fertilizing matters is to cart the manure directly on the field whenever circumstances allow this to be done.

"7. On all soils with a moderate proportion of clay, no fear need to be entertained of valuable fertilizing substances becoming wasted if the manure cannot be plowed in at once. Fresh, and even well-rotten, dung contains very little free ammonia; and since active fermentation, and with it the further evolution of free ammonia, is stopped by spreading out the manure on the field, valuable volatile manuring matters can not escape into the air by adopting this plan.

"As all soils with a moderate proportion of clay possess in a remarkable degree the power of absorbing and retaining manuring matters, none of the saline and soluble organic constituents are wasted even by a heavy fall of rain. It may, indeed, be questioned whether it is more advisable to plow in the manure at once, or to let it lie for some time on the surface, and to give the rain full opportunity to wash it into the soil.

"It appears to me a matter of the greatest importance to regulate the application of manure to our fields, so that its constituents may become properly diluted and uniformly distributed amongst a large mass of soil. By plowing in the manure at once, it appears to me, this desirable end can not be reached so perfectly as by allowing the rain to wash in gradually the manure evenly spread on the surface of the field.

"By adopting such a course, in case practical experience should confirm my theoretical reasoning, the objection could no longer be maintained that the land is not ready for carting manure upon it. I am inclined to recommend, as a general rule: Cart the manure on the field, spread it at once, and wait for a favorable opportunity to plow it in. In the case of clay soils, I have no hesitation to say the manure may be spread even six months before it is plowed in, without losing any appreciable quantity in manuring matter.

"I am perfectly aware, that on stiff clay land, farm-yard manure, more especially long dung, when plowed in before the frost sets in, exercises a most beneficial action by keeping the soil loose, and admitting the free access of frost, which pulverizes the land, and would, therefore, by no means recommend to leave the manure spread on the surface without plowing it in. All I wish to enforce is, that when no other choice is left but either to set up the manure in a heap in a corner of the field, or to spread it on the field, without plowing it in directly, to adopt the latter plan. In the case of very light sandy soils, it may perhaps not be advisable to spread out the manure a long time before it is plowed in, since such soils do not possess the power of retaining manuring matters in any marked degree. On light sandy soils, I would suggest to manure with well-fermented dung, shortly before the crop intended to be grown is sown.

"8. Well-rotten dung contains, likewise, little free ammonia, but a very much larger proportion of soluble organic and saline mineral matters than fresh manure.

"9. Rotten dung is richer in nitrogen than fresh.

"10. Weight for weight, rotten dung is more valuable than fresh.

"11. In the fermentation of dung, a very considerable proportion of the organic matters in fresh manure is dissipated into the air in the form of carbonic acid and other gases.

"12. Properly regulated, however, the fermentation of dung is not attended with any great loss of nitrogen, nor of saline mineral matters.

"13. During the fermentation of dung, ulmic, humic, and other organic acids are formed, as well as gypsum, which fix the ammonia generated in the decomposition of the nitrogenized constituents of dung.

"14. During the fermentation of dung, the phosphate of lime which it contains is rendered more soluble than in fresh manure.

"15. In the interior and heated portions of manure-heaps, ammonia is given off; but, on passing into the external and cold layers of dung-heaps, the free ammonia is retained in the heap.

"16. Ammonia is not given off from the surface of well-compressed dung-heaps, but on turning manure-heaps, it is wasted in appreciable quantities. Dung-heaps, for this reason, should not be turned more frequently than absolutely necessary.

"17. No advantage appears to result from carrying on the fermentation of dung too far, but every disadvantage.

"18. Farm-yard manure becomes deteriorated in value, when kept in heaps exposed to the weather, the more the longer it is kept.

"19. The loss in manuring matters, which is incurred in keeping manure-heaps exposed to the weather, is not so much due to the volatilization of ammonia as to the removal of ammoniacal salts, soluble nitrogenized organic matters, and valuable mineral matters, by the rain which falls in the period during which the manure is kept.

"20. If rain is excluded from dung-heaps, or little rain falls at a time, the loss in ammonia is trifling, and no saline matters, of course, are removed; but, if much rain falls, especially if it descends in heavy showers upon the dung-heap, a serious loss in ammonia, soluble organic matter, phosphate of lime, and salts of potash is incurred, and the manure becomes rapidly deteriorated in value, whilst at the same time it is diminished in weight.

"21. Well-rotten dung is more readily affected by the deteriorating influence of rain than fresh manure.

"22. Practically speaking, all the essentially valuable manuring constituents are preserved by keeping farm-yard manure under cover.

"23. If the animals have been supplied with plenty of litter, fresh dung contains an insufficient quantity of water to induce an active fermentation. In this case, fresh dung can not be properly fermented under cover, except water or liquid manure is pumped over the heap from time to time.

" Where much straw is used in the manufacture of dung, and no provision is made to supply the manure in the pit at any time with the requisite amount of moisture, it may not be advisable to put up a roof over the dung-pit. On the other hand, on farms where there is a deficiency of straw, so that the moisture of the excrements of our domestic animals is barely absorbed by the litter, the advantage of erecting a roof over the dung-pit will be found very great.

" 24. The worst method of making manure is to produce it by animals kept in open yards, since a large proportion of valuable fertilizing matters is wasted in a short time; and after a lapse of twelve months, at least two-thirds of the substance of the manure is wasted, and only one-third, inferior in quality to an equal weight of fresh dung, is left behind.

" 25. The most rational plan of keeping manure in heaps appears to me that adopted by Mr. Lawrence, of Cirencester, and described by him at length in Morton's 'Cyclopædia of Agriculture,' under the head of 'Manure.' "

CHAPTER XVI.

AN ENGLISH PLAN OF KEEPING MANURE.

" I would like to know," said the Deacon, " how Mr. Lawrence manages his manure, especially as his method has received such high commendation."

Charley got the second volume of "Morton's Cyclopædia of Agriculture," from the book shelves, and turned to the article on " Manure." He found that Mr. Lawrence adopted the "Box System" of feeding cattle, and used cut or chaffed straw for bedding. And Mr. Lawrence claims that by this plan " manure will have been made under the most perfect conditions." And " when the boxes are full at those periods of the year at which manure is required for the succeeding crops, it will be most advantageously disposed of by being transferred at once to the land, and covered in."

" Good, said the Deacon, " I think he is right there." Charley continued, and read as follows:

" But there will be accumulations of manure requiring removal from the homestead at other seasons, at which it cannot be so applied, and when it must be stored for future use. The following has been found an effectual and economical mode of accomplishing this; more particularly when cut litter is used, it saves the cost of repeated turnings, and effectually prevents the decomposition and waste of the most active and volatile principle.

"Some three or more spots are selected according to the size of the farm, in convenient positions for access to the land under tillage, and by the side of the farm roads The sites fixed on are then excavated about two feet under the surrounding surface. In the bottom is laid some three or four inches of earth to absorb any moisture, on which the manure is emptied from the carts. This is evenly spread, and well trodden as the heap is forming. As soon as this is about a foot above the ground level, to allow for sinking, the heap is gradually gathered in, until it is completed in the form of an ordinary steep roof, slightly rounded at the top by the final treading. In the course of building this up, about a bushel of salt, to two cart-loads of dung is sprinkled amongst it. The base laid out at any one time should not exceed that required by the manure ready for the complete formation of the heap as far as it goes; and within a day or two after such portion is built up, and it has settled into shape, a thin coat of earth in a moist state is plastered *entirely* over the surface. Under these conditions decomposition does not take place, in consequence of the exclusion of the air; or at any rate to so limited an extent, that the ammonia is absorbed by the earth, for there is not a trace of it perceptible about the heap; though, when put together without such covering, this is perceptible enough to leeward at a hundred yards' distance.

"When heaps thus formed are resorted to in the autumn, either for the young seeds, or for plowing in on the stubbles after preparing for the succeeding root crop, the manure will be found undiminished in quantity and unimpaired in quality; in fact, simply consolidated. Decomposition then proceeds within the soil, where all its results are appropriated, and rendered available for the succeeding cereal as well as the root crop.

"It would be inconvenient to plaster the heap, were the ridge, when settled, above six or seven feet from the ground level; the base may be formed about ten to twelve feet wide, and the ridge about nine feet from the base, which settles down to about seven feet; this may be extended to any length as further supplies of manure require removal. One man is sufficient to form the heap, and it is expedient to employ the same man for this service, who soon gets into the way of performing the work neatly and quickly.

It has been asked where a farmer is to get the earth to cover his heaps—it may be answered, keep your roads scraped when they get muddy on the surface during rainy weather—in itself good economy—and leave this in small heaps beyond the margin of your roads. This, in the course of the year, will be found an ample provision for the purpose, for it is unnecessary to lay on a coat more than one or two inches in thickness, which should be done when in a moist state. At any rate, there will always be found an accumulation on headlands that may be drawn upon if need be.

"Farmers who have not been in the habit of bestowing care on the manufacture and subsequent preservation of their manure, and watching results, have no conception of the importance of this. A barrowful of such manure as has been described, would produce a greater weight of roots and corn, than that so graphically described by the most talented and accomplished of our agricultural authors—as the contents of 'neighbour Drychaff's dung-cart, that creaking hearse, that is carrying to the field the dead body whose spirit has departed.'

"There is a source of valuable and extremely useful manure on every farm, of which very few farmers avail themselves—the gathering together in one spot of all combustible waste and rubbish, the clippings of hedges, scouring of ditches, grassy accumulation on the sides of roads and fences, etc., combined with a good deal of earth. If these are carted at leisure times into a large circle, or in two rows, to supply the fire kindled in the center, in a spot which is frequented by the laborers on the farm, with a three-pronged fork and a shovel attendant, and each passer-by is encouraged to add to the pile whenever he sees the smoke passing away so freely as to indicate rapid combustion, a very large quantity of valuable ashes are collected between March and October. In the latter month the fire should be allowed to go out; the ashes are then thrown into a long ridge, as high as they will stand, and thatched while dry. This will be found an invaluable store in April, May, and June, capable of supplying from twenty to forty bushels of ashes per acre, according to the care and industry of the collector, to drill with the seeds of the root crop."

The Deacon got sleepy before Charley finished reading. "We can not afford to be at so much trouble in this country," he said, and took up his hat and left.

The Deacon is not altogether wrong. Our climate is very different from that of England, and it is seldom that farmers need to draw out manure, and pile it in the field, except in winter, and then it is not necessary, I think, either to dig a pit or to cover the heap. Those who draw manure from the city in summer, may probably adopt some of Mr. Lawrence's suggestions with advantage.

The plan of collecting rubbish, brush, old wood, and sods, and converting them into ashes or charcoal, is one which we could often adopt with decided advantage. Our premises would be cleaner, and we should have less fungus to speck and crack our apples and pears, and, in addition, we should have a quantity of ashes or burnt earth, that is not only a manure itself, but is specially useful to mix with moist superphosphate and other artificial manures, to make them dry enough and bulky enough to be easily and evenly distributed by the drill. Artificial manures, so mixed with these ashes, or dry, charred earth, are less likely to injure the seed than when sown with the seed in the drill-rows, unmixed with some such material. Sifted coal ashes are also very useful for this purpose.

CHAPTER XVII.

SOLUBLE PHOSPHATES IN FARM-YARD MANURE.

There is one thing in these experiments of Dr. Vœlcker's which deserves special attention, and that is the comparatively large amount of *soluble phosphate of lime* in the ash of farm-yard manure. I do not think the fact is generally known. In estimating the value of animal manures, as compared with artificial manures, it is usually assumed that the phosphates in the former are insoluble, and, therefore, of less value than the soluble phosphates in superphosphate of lime and other artificial manures.

Dr. Vœlcker found in the ash of *fresh* farm-yard manure, phosphoric acid equal to 12.23 per cent of phosphate of lime, and of this 5.35 was *soluble* phosphate of lime.

In the ash of well-rotted manure, he found phosphoric acid equal to 12.11 per cent of phosphate of lime, and of this, 4.75 was soluble phosphate of lime.

"That is, indeed, an important fact," said the Doctor, "but I thought Professor Vœlcker claimed that 'during the fermentation of dung, the phosphate of lime which it contains is rendered more soluble than in fresh manure.'"

"He did say so," I replied, "and it may be true, but the above figures do not seem to prove it. When he wrote the sentence you have quoted, he probably had reference to the fact that he found more soluble phosphate of lime in rotted manure than in fresh manure. Thus, he found in 5 tons of fresh and 5 tons of rotted manure, the following ingredients:

5 TONS, (10,000 LBS.)	*Soluble Phosphate of Lime.*	*Insoluble Phosphates.*	*Total Phosphates.*	*Potash.*		*Total Soluble Ash.*	*Total Insoluble Ash.*	*Total Ash.*
				Sol.	*Insol.*			
Fresh manure..........................	29.9	38.6	68.5	57.3	9.9	154	405	559
Rotted manure........................	38.2	57.3	95.5	44.6	4.5	147	658	805

"It will be seen from the above figures that *rotted manure contains more soluble phosphate of lime than fresh manure.*

"But it does not follow from this fact that any of the insoluble phosphates in fresh manure have been rendered soluble during the fermentation of the manure.

"There are more insoluble phosphates in the rotted manure than in the fresh, but we do not conclude from this fact that any of the phosphates have been rendered insoluble during the process of fermentation—neither are we warranted in concluding that any of them have been rendered soluble, simply because we find more soluble phosphates in the rotted manure."

"Very true," said the Doctor, "but it has been shown that *in the heap* of manure, during fermentation, there was an *actual increase* of soluble mineral matter during the first six months, and, to say the least, it is highly probable that some of this increase of soluble mineral matter contained more or less soluble phosphates, and perhaps Dr. Vœlcker had some facts to show that such was the case, although he may not have published them. At any rate, he evidently thinks that the phosphates in manure are rendered more soluble by fermentation."

"Perhaps," said I, "we can not do better than to let the matter rest in that form. I am merely anxious not to draw definite conclusions from the facts which the facts do not positively prove. I am strongly in favor of fermenting manure, and should be glad to have it shown that fermentation does actually convert insoluble phosphates into a soluble form."

There is one thing, however, that these experiments clearly prove, and that is, that there is a far larger quantity of *soluble*

4

phosphates in manure than is generally supposed. Of the total phosphoric acid in the fresh manure, 43 per cent is in a soluble condition; and in the rotted manure, 40 per cent is soluble.

This is an important fact, and one which is generally overlooked. It enhances the value of farm-yard or stable manure, as compared with artificial manures. But of this we may have more to say when we come to that part of the subject. I want to make one remark. I think there can be little doubt that the proportion of soluble phosphates is greater in rich manure, made from grain-fed animals, than in poor manure made principally from straw. In other words, of 100 lbs. of total phosphoric acid, more of it would be in a soluble condition in the rich than in the poor manure.

CHAPTER XVIII.

HOW THE DEACON MAKES MANURE.

"I think," said the Deacon, "you are talking too much about the science of manure making. Science is all well enough, but practice is better."

"That depends," said I, "on the practice. Suppose you tell us how you manage your manure."

"Well," said the Deacon, "I do not know much about plant-food, and nitrogen, and phosphoric acid, but I think manure is a good thing, and the more you have of it the better. I do not believe in your practice of spreading manure on the land and letting it lie exposed to the sun and winds. I want to draw it out in the spring and plow it under for corn. I think this long, coarse manure loosens the soil and makes it light, and warm, and porous. And then my plan saves labor. More than half of my manure is handled but once. It is made in the yard and sheds, and lies there until it is drawn to the field in the spring. The manure from the cow and horse stables, and from the pig-pens, is thrown into the yard, and nothing is done to it except to level it down occasionally. In proportion to the stock kept, I think I make twice as much manure as you do."

"Yes," said I, "twice as much *in bulk*, but one load of my manure is worth four loads of your long, coarse manure, composed principally of corn-stalks, straw, and water. I think you are wise in not spending much time in piling and working over such manure."

The Deacon and I have a standing quarrel about manure. We differ on all points. He is a good man, but not what we call a good farmer. He cleared up his farm from the original forest, and he has always been content to receive what his land would give him. If he gets good crops, well, if not, his expenses are moderate, and he manages to make both ends meet. I tell him he could double his crops, and quadruple his profits, by better farming—but though he cannot disprove the facts, he is unwilling to make any change in his system of farming. And so he continues to make just as much manure as the crops he is obliged to feed out leave in his yards, and no more. He does not, in fact, *make* any manure. He takes what comes, and gets it on to his land with as little labor as possible.

It is no use arguing with such a man. And it certainly will not do to contend that his method of *managing* manure is all wrong. His error is in making such poor manure. But with such poor stuff as he has in his yard, I believe he is right to get rid of it with the least expense possible.

I presume, too, that the Deacon is not altogether wrong in regard to the good mechanical effects of manure on undrained and indifferently cultivated land. I have no doubt that he bases his opinion on experience. The good effects of such manure as he makes must be largely due to its mechanical action—it can do little towards supplying the more important and valuable elements of plant-food.

I commend the Deacon's system of managing manure to all such as make a similar article. But I think there is a more excellent way. Feed the stock better, make richer manure, and then it will pay to bestow a little labor in taking care of it.

CHAPTER XIX.

HOW JOHN JOHNSTON MANAGES HIS MANURE.

One of the oldest and most successful farmers, in the State of New York, is John Johnston, of Geneva. He has a farm on the borders of Seneca Lake. It is high, rolling land, but needed under draining. This has been thoroughly done—and done with great profit and advantage. The soil is a heavy clay loam. Mr. Johnston has been in the habit of summer-fallowing largely for wheat, generally plowing three, and sometimes four times. He has been a very successful wheat-grower, almost invariably obtaining large crops of wheat, both of grain and straw. The straw he feeds to sheep in winter, putting more straw in the racks than the sheep can eat up clean, and using what they leave for bedding. The sheep run in yards enclosed with tight board fences, and have sheds under the barn to lie in at pleasure.

Although the soil is rather heavy for Indian corn, Mr. Johnston succeeds in growing large crops of this great American cereal. Corn and stalks are both fed out on the farm. Mr. J. has not yet practised cutting up his straw and stalks into chaff.

The land is admirably adapted to the growth of red clover, and great crops of clover and timothy-hay are raised, and fed out on the farm. Gypsum, or plaster, is sown quite freely on the clover in the spring. Comparatively few roots are raised—not to exceed an acre—and these only quite recently. The main crops are winter wheat, spring barley, Indian corn, clover, and timothy-hay, and clover-seed.

The materials for making manure, then, are wheat and barley straw, Indian corn, corn-stalks, clover, and timothy-hay. These are all raised on the farm. But Mr. Johnston has for many years purchased linseed-oil cake, to feed to his sheep and cattle.

This last fact must not be overlooked. Mr. J. commenced to feed oil-cake when its value was little known here, and when he bought it for, I think, seven or eight dollars a ton. He continued to use it even when he had to pay fifty dollars per ton. Mr. J. has great faith in manure—and it is a faith resting on good evidence and long experience. If he had not fed out so much oil-cake and clover-hay, he would not have found his manure so valuable.

"How much oil-cake does he use?" asked the Deacon.

"He gives his sheep, on the average, about 1 lb. each per day."

If he feeds out a ton of clover-hay, two tons of straw, (for feed and bedding,) and one ton of oil-cake, the manure obtained from this quantity of food and litter, would be worth, according to Mr. Lawes' table, given on page 45, $34.72.

On the other hand, if he fed out one ton of corn, one ton of clover-hay, and two tons of straw, for feed and bedding, the manure would be worth $21.65.

If he fed one ton of corn, and three tons of straw, the manure would be worth only $14.69.

He would get *as much manure* from the three tons of straw and one ton of corn, as from the two tons of straw, one ton of clover-hay, and one ton of oil-cake, while, as before said, the manure in the one case would be worth $14.69, and in the other $34.72.

In other words, a load of the good manure would be worth, when spread out on the land in the field or garden, more than two loads of the straw and corn manure.

To get the same amount of nitrogen, phosphoric acid, and potash, you have to spend more than twice the labor in cleaning out the stables or yards, more than twice the labor of throwing or wheeling it to the manure pile, more than twice the labor of turning the manure in the pile, more than twice the labor of loading it on the carts or wagons, more than twice the labor of drawing it to the field, more than twice the labor of unloading it into heaps, and more than twice the labor of spreading it in the one case than in the other, and, after all, twenty tons of this poor manure would not produce as good an effect the first season as ten tons of the richer manure.

"Why so"? asked the Deacon.

"Simply because the poor manure is not so active as the richer manure. It will not decompose so readily. Its nitrogen, phosphoric acid, and potash, are not so available. The twenty tons, *may*, in the long run, do as much good as the ten tons, but I very much doubt it. At any rate, I would greatly prefer the ten tons of the good manure to twenty tons of the poor—even when spread out on the land, ready to plow under. What the difference would be in the value of the manure *in the yard*, you can figure for yourself. It would depend on the cost of handling, drawing, and spreading the extra ten tons."

The Deacon estimates the cost of loading, drawing, unloading, and spreading, at fifty cents a ton. This is probably not far out of the way, though much depends on the distance the manure has to be drawn, and also on the condition of the manure, etc.

The four tons of feed and bedding will make, at a rough estimate, about ten tons of manure.

This ten tons of straw and corn manure, according to Mr. Lawes' estimate, is worth, *in the field*, $14.69. And if it costs fifty cents a load to get it on the land its value, *in the yard*, would be $9.69—or nearly ninety-seven cents a ton.

The ten tons of good manure, according to the same estimate, is worth, *in the field*, $34.72, and, consequently, would be worth, *in the yard*, $29.72. In other words, a ton of poor manure is worth, in the yard, ninety-seven cents a ton, and the good manure $2.97.

And so in describing John Johnston's method of managing manure, this fact must be borne in mind. It might not pay the Deacon to spend much labor on manure worth only ninety-seven cents a ton, while it might pay John Johnston to bestow some considerable time and labor on manure worth $2.97 per ton.

"But is it really worth this sum?" asked the Deacon.

"In reply to that," said I, "all I claim is that the figures are comparative. If your manure, made as above described, is worth ninety-seven cents a ton in the yard, *then* John Johnston's manure, made as stated, is *certainly* worth, at least, $2.97 per ton in the yard."

Of this there can be no doubt.

"If you think," I continued, "your manure, so made, is worth only half as much as Mr. Lawes' estimate; in other words, if your ten tons of manure, instead of being worth $14.69 in the field, is worth only $7.35; then John Johnston's ten tons of manure, instead of being worth $34.72 in the field, is worth only $17.36."

"That looks a little more reasonable," said the Deacon, "John Johnston's manure, instead of being worth $2.97 per ton in the yard, is worth only $1 48 per ton, and mine, instead of being worth ninety-seven cents a ton, is worth forty-eight and a half cents a ton."

The Deacon sat for a few minutes looking at these figures. "They do not seem so extravagantly high as I thought them at first," he said, "and if you will reduce the figures in Mr. Lawes' table one-half all through, it will be much nearer the truth. I think my manure is worth forty-eight and a half cents a ton in the yard, and if your figures are correct, I suppose I must admit that John Johnston's manure is worth $1.48 per ton in the yard."

I was very glad to get such an admission from the Deacon. He did not see that he had made a mistake in the figures, and so I got him to go over the calculation again.

"You take a pencil, Deacon," said I, "and write down the figures:

Manure from a ton of oil-cake	$19.72
Manure from a ton of clover-hay	9.64
Manure from two tons of straw	5.36
	$34.72

"This would make about ten tons of manure. We have agreed to reduce the estimate one-half, and consequently we have $17.36 as the value of the ten tons of manure."

"This is John Johnston's manure. It is worth $1.73 per ton in the field.

"It costs, we have estimated, 50 cents a ton to handle the manure, and consequently it is worth in the yard $1.23 per ton."

"This is less than we made it before," said the Deacon.

"Never mind that," said I, "the figures are correct. Now write down what your manure is worth:

Manure from 1 ton of corn	$6.65
Manure from 3 tons of straw	8.04
	$14.69

"This will make about ten tons of manure. In this case, as in the other, we are to reduce the estimate one-half. Consequently, we have $7.35 as the value of this ten tons of manure in the field, or 73½ cents a ton. It costs, we have estimated, 50 cents a ton to handle the manure, and, therefore, it is worth *in the yard*, 23½ cents a ton."

"John Johnston's manure is worth in the yard, $1.23 per ton. The Deacon's manure is worth in the yard, 23½ cents per ton."

"There is some mistake," exclaimed the Deacon, "you said, at first, that one load of John Johnston's manure was worth as much as two of my loads. Now you make one load of his manure worth more than five loads of my manure. This is absurd."

"Not at all, Deacon," said I, "you made the figures yourself. You thought Mr. Lawes' estimate too high. You reduced it one-half. The figures are correct, and you must accept the conclusion. If John Johnston's manure is only worth $1.23 per ton in the yard, yours, made from 1 ton of corn and 3 tons of straw, is only worth 23½ cents per ton."

"And now, Deacon," I continued, "while you have a pencil in your hand, I want you to make one more calculation. Assuming that Mr. Lawes' estimate is too high, and we reduce it one-half, figure up what manure is worth when made from straw alone. You take 4 tons of wheat straw, feed out part, and use part for bedding. It will give you about 10 tons of manure. And this 10 tons cost you 50 cents a ton to load, draw out, and spread. Now figure:

"Four tons of straw is worth, for manure, according to Mr. Lawes' table, $2.68 per ton. We have agreed to reduce the figures one-half, and so the

10 tons of manure from the 4 tons of straw is worth...	$5.36
Drawing out 10 tons of manure at 50 cents............	5.00
Value of 10 tons of straw-manure *in yard*..............	$0.36

"In other words, if John Johnston's manure is worth only $1.23 per ton in the yard, the straw-made manure is worth only a little over 3½ cents a ton in the yard."

"That is *too* absurd," said the Deacon.

"Very well," I replied, "for once I am glad to agree with you. But if this is absurd, then it follows that Mr. Lawes' estimate of the value of certain foods for manure is not so extravagant as you supposed—which is precisely what I wished to prove."

"You have not told us how Mr. Johnston manages his manure," said the Deacon.

"There is nothing very remarkable about it," I replied. "There are many farmers in this neighborhood who adopt the same method. I think, however, John Johnston was the first to recommend it, and subjected himself to some criticism from some of the so-called scientific writers at the time.

"His general plan is to leave the manure in the yards, basements, and sheds, under the sheep, until spring. He usually sells his fat sheep in March. As soon as the sheep are removed, the manure is either thrown up into loose heaps in the yard, or drawn directly to the field, where it is to be used, and made into a heap there. The manure is not spread on the land until the autumn. It remains in the heaps or piles all summer, being usually turned once, and sometimes twice. The manure becomes thoroughly rotted."

Mr. Johnston, like the Deacon, applies his manure to the corn crop. But the Deacon draws out his fresh green manure in the spring, on sod-land, and plows it under. Mr. Johnston, on the other hand, keeps his manure in a heap through the summer, spreads it on the sod in September, or the first week in October. Here it lies until next spring. The grass and clover grow up through manure, and the grass and manure are turned under next spring, and the land planted to corn.

Mr. Johnston is thoroughly convinced that he gets far more benefit from the manure when applied on the surface, and left exposed for several months, than if he plowed it under at once.

I like to write and talk about John Johnston. I like to visit him. He is so delightfully enthusiastic, believes so thoroughly in good farming, and has been so eminently successful, that a day spent in his company can not fail to encourage any farmer to renewed efforts in improving his soil. "You *must* drain," he wrote to me; "when I first commenced farming, I never made any money until I began to underdrain." But it is not underdraining alone that is the cause of his eminent success. When he bought his farm, "near Geneva," over fifty years ago, there was a pile of manure in the yard that had lain there year after year, until it was, as he said, "as black as my hat." The former owner regarded it as a nuisance, and a few months before young Johnston bought the farm, had given some darkies a cow on condition that they would draw out this manure. They drew out six loads, took the cow—and that was the last seen of them. Johnston drew out this manure, raised a good crop of wheat, and that gave him a start. He says he has been asked a great many times to what he owes his success as a farmer, and he has replied that he could not tell whether it was "dung or credit." It was probably neither. It was the man—his intelligence, industry, and good common sense. That heap of black mould was merely an instrument in his hands that he could turn to good account.

His first crop of wheat gave him "credit," and this also he used to advantage. He believed that good farming would pay, and it was this faith in a generous soil that made him willing to spend the money obtained from the first crop of wheat in enriching the land, and to avail himself of his credit. Had he lacked this faith—had he hoarded every sixpence he could have ground out of the soil, who would have ever heard of John Johnston? He has been liberal with his crops and his animals, and has ever found them grateful. This is the real lesson which his life teaches.

He once wrote me he had something to show me. He did not tell me what it was, and when I got there, he took me to a field of grass that was to be mown for hay. The field had been in winter wheat the year before. At the time of sowing the wheat, the whole field was seeded down with timothy. No clover was sown either then or in the spring; but after the wheat was sown, he put on a slight dressing of manure on two portions of the field that he thought were poor. He told the man to spread it out of the wagon just as thin as he could distribute it evenly over the land. It was a very light manuring, but the manure was rich, and thoroughly rotted. I do not recollect whether the effect of the manure was particularly noticed on the wheat; but on the grass, the following spring, the effect was sufficiently striking. Those two portions of the field where the manure was spread were *covered with a splendid crop of red clover.* You could see the exact line, in both cases, where the manure reached. It looked quite curious. No clover-seed was sown, and yet there was as fine a crop of clover as one could desire.

On looking into the matter more closely, we found that there was more or less clover all over the field, but where the manure was not used, it could hardly be seen. The plants were small, and the timothy hid them from view. But where the manure was used, these plants of clover had been stimulated in their growth until they covered the ground. The leaves were broad and vigorous, while in the other case they were small, and almost dried up. This is probably the right explanation. The manure did not "bring in the clover;" it simply increased the growth of that already in the soil. It shows the value of manure for grass.

This is what Mr. Johnston wanted to show me. "I might have written and told you, but you would not have got a clear idea of the matter." This is true. One had to see the great luxuriance of that piece of clover to fully appreciate the effect of the manure. Mr. J. said the manure on that grass was worth $30 an acre—that is, on the three crops of grass, before the field is again plowed. I have no doubt that this is true, and that the future crops on the land will also be benefited—not directly from the manure, perhaps, but from the clover-roots in the soil. And if the field were pastured, the effect on future crops would be very decided.

CHAPTER XX.

MY OWN PLAN OF MANAGING MANURE.

One of the charms and the advantages of agriculture is that a farmer must think for himself. He should study principles, and apply them in practice, as best suits his circumstances.

My own method of managing manure gives me many of the advantages claimed for the Deacon's method, and John Johnston's, also.

"I do not understand what you mean," said the Deacon; "my method differs essentially from that of John Johnston."

"True," I replied, "you use your winter-made manure in the spring; while Mr. Johnston piles his, and gets it thoroughly fermented; but to do this, he has to keep it until the autumn, and it does not benefit his corn-crop before the next summer. He loses the use of his manure for a year."

I think my method secures both these advantages. I get my winter-made manure fermented and in good condition, and yet have it ready for spring crops.

In the first place, I should remark that my usual plan is to cut up all the fodder for horses, cows, and sheep. For horses, I sometimes use long straw for bedding, but, as a rule, I prefer to run everything through a feed-cutter. We do not steam the food, and we let the cows and sheep have a liberal supply of cut corn-stalks and straw, and what they do not eat is thrown out of the mangers and racks, and used for bedding.

I should state, too, that I keep a good many pigs, seldom having less than 50 breeding sows. My pigs are mostly sold at from two to four months old, but we probably average 150 head the year round. A good deal of my manure, therefore, comes from the pig-pens, and from two basement cellars, where my store hogs sleep in winter.

In addition to the pigs, we have on the farm from 150 to 200 Cotswold and grade sheep; 10 cows, and 8 horses. These are our manure makers.

The raw material from which the manure is manufactured consists of wheat, barley, rye, and oat-straw, corn-stalks, corn-fodder, clover and timothy-hay, clover seed-hay, bean-straw, pea-straw, potato-tops, mangel-wurzel, turnips, rape, and mustard. These are all raised on the farm; and, in addition to the home-grown oats, peas, and corn, we buy and feed out considerable quantities of bran, shorts, fine-middlings, malt-combs, corn-meal, and a little oil-cake. I sell wheat, rye, barley, and clover-seed, apples, and potatoes, and sometimes cabbages and turnips. Probably, on the average, for each $100 I receive from the sale of these crops, I purchase $25 worth of bran, malt-combs, corn-meal, and other feed for animals. My farm is now rapidly increasing in fertility and productiveness. The crops, on the average, are certainly at least double what they were when I bought the farm thirteen years ago; and much of this increase has taken place during the last five or six years, and I expect to see still greater improvement year by year.

"Never mind all that," said the Deacon; "we all know that manure will enrich land, and I will concede that your farm has greatly improved, and can not help but improve if you continue to make and use as much manure."

"I expect to make more and more manure every year," said I. "The larger the crops, the more manure we can make; and the more manure we make, the larger the crops."

The real point of difference between my plan of managing manure, and the plan adopted by the Deacon, is essentially this: I aim to keep all my manure in a compact pile, where it will slowly ferment all winter. The Deacon throws his horse-manure into a heap, just outside the stable door, and the cow-manure into another heap, and the pig-manure into another heap. These heaps are more or less scattered, and are exposed to the rain, and snow, and frost. The horse-manure is quite likely to ferment too rapidly, and if in a large heap, and the weather is warm, it not unlikely "fire-fangs" in the center of the heap. On the other hand, the cow-manure lies cold and dead, and during the winter freezes into solid lumps.

I wheel or cart all my manure into one central heap. The main object is to keep it as compact as possible. There are two advantages in this: 1st, the manure is less exposed to the rain, and (2d), when freezing weather sets in, only a few inches of the external portion of the heap is frozen. I have practised this plan for several years, and can keep my heap of manure slowly fermenting during the whole winter.

But in order to ensure this result, it is necessary to begin making the heap before winter sets in. The plan is this:

Having selected the spot in the yard most convenient for making the heap, collect all the manure that can be found in the sheep-yards, sheds, cow and horse stables, pig-pens, and hen-house, together with leaves, weeds, and refuse from the garden, and wheel or cart it to the intended heap. If you set a farm-man to do the work, tell him you want to make a hot-bed about five feet high, six feet wide, and six feet long. I do not think I have ever seen a farm where enough material could not be found, say in November, to make such a heap. And this is all that is needed. If the manure is rich, if it is obtained from animals eating clover-hay, bran, grain, or other food rich in nitrogen, it will soon ferment. But if the manure is poor, consisting largely of straw, it will be very desirable to make it richer by mixing with it bone-dust, blood, hen-droppings, woollen rags, chamber-lye, and animal matter of any kind that you can find.

The richer you can make the manure, the more readily will it ferment. A good plan is to take the horse or sheep manure, a few weeks previous, and use it for bedding the pigs. It will absorb the liquid of the pigs, and make rich manure, which will soon ferment when placed in a heap.

If the manure in the heap is too dry, it is a good plan, when you are killing hogs, to throw on to the manure all the warm water, hair, blood, intestines, etc. You may think I am making too much of such a simple matter, but I have had letters from farmers who have tried this plan of managing manure, and they say that they can not keep it from freezing. One reason for this is, that they do not start the heap early enough, and do not take pains to get the manure into an active fermentation before winter sets in. Much depends on this. In starting a fire, you take pains to get a little fine, dry wood, that will burn readily, and when the fire is fairly going, put on larger sticks, and presently you have such a fire that you can burn wood, coal, stubble, sods, or anything you wish. And so it is with a manure-heap. Get the fire, or fermentation, or, more strictly speaking, putrefaction fairly started, and there will be little trouble, if the heap is large enough, and fresh material is added from time to time, of continuing the fermentation all winter.

Another point to be observed, and especially in cold weather, is to keep the sides of the heap straight, and the *top level.* You must expose the manure in the heap as little as possible to frost and cold winds. The rule should be to spread every wheel-barrowful of manure as soon as it is put on the heap. If left unspread on top of the heap, it will freeze; and if afterwards covered with other manure, it will require considerable heat to melt it, and thus reduce the temperature of the whole heap.

It is far less work to manage a heap of manure in this way than may be supposed from my description of the plan. The truth is, I find, in point of fact, that it is *not* an easy thing to manage manure in this way; and I fear not one farmer in ten will succeed the first winter he undertakes it, unless he gives it his personal attention. It is well worth trying, however, because if your heap should freeze up, it will be, at any rate, in no worse condition than if managed in the ordinary way; and if you do succeed, even in part, you will have manure in good condition for immediate use in the spring.

As I have said before, I keep a good many pigs. Now pigs, if fed on slops, void a large quantity of liquid manure, and it is not always easy to furnish straw enough to absorb it. When straw and stalks are cut into chaff, they will absorb much more liquid than when used whole. For this reason we usually cut all our straw and stalks. We also use the litter from the horse-stable for bedding the store hogs, and also sometimes, when comparatively dry, we use the refuse sheep bedding for the same purpose. Where the sheep barn is contiguous to the pig-pens, and when the sheep bedding can be thrown at once into the pig-pens or cellar, it is well to use bedding freely for the sheep and lambs, and remove it frequently, throwing it into the pig-pens. I do not want my sheep to be compelled to eat up the straw and corn-stalks too close. I want them to pick out what they like, and then throw away what they leave in the troughs for bedding. Sometimes we take out a five-bushel basketful of these direct from the troughs, for bedding young pigs, or sows and pigs in the pens, but as a rule, we use them first for bedding the sheep, and then afterwards use the sheep bedding in the fattening or store pig-pens.

"And sometimes," remarked the Deacon, "you use a little long straw for your young pigs to sleep on, so that they can bury themselves in the straw and keep warm."

"True," I replied, "and it is not a bad plan, but we are not now talking about the management of pigs, but how we treat our manure, and how we manage to have it ferment all winter."

A good deal of our pig-manure is, to borrow a phrase from the pomologists, "double-worked." It is horse or sheep-manure, used for bedding pigs and cows. It is saturated with urine, and is much richer in nitrogenous material than ordinary manure, and consequently will ferment or putrify much more rapidly. Usually pig-manure is considered "cold," or sluggish, but this double-worked pig-manure will ferment even more rapidly than sheep or horse-manure alone.

Unmixed cow-manure is heavy and cold, and when kept in a heap by itself out of doors, is almost certain to freeze up solid during the winter.

We usually wheel out our cow-dung every day, and spread on the manure heap.

This is one of the things that needs attention. There will be a constant tendency to put all the cow-dung together, instead of mixing it with the lighter and more active manure from the horses, sheep, and pigs. Spread it out and cover it with some of the more strawy manure, which is not so liable to freeze.

Should it so happen—as will most likely be the case—that on looking at your heap some morning when the thermometer is below zero, you find that several wheel-barrowfuls of manure that were put on the heap the day before, were not spread, and are now crusted over with ice, it will be well to break up the barrowfuls, even if necessary to use a crowbar, and place the frozen lumps of manure on the outside of the heap, rather than to let them lie in the center of the pile. Your aim should be always to keep the center of the heap warm and in a state of fermentation. You do not want the fire to go out, and it will not go out if the heap is properly managed, even should all the sides and top be crusted over with a layer of frozen manure.

During very severe weather, and when the top is frozen, it is a good plan, when you are about to wheel some fresh manure on to the heap, to remove a portion of the frozen crust on top of the heap, near the center, and make a hole for the fresh manure, which should be spread and covered up.

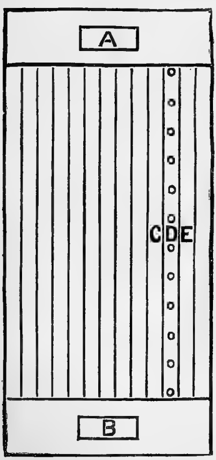
When the heap is high enough, say five feet, we commence another heap alongside. In doing this, our plan is to clean out some of the sheep-sheds or pig-pens, where the manure has accumulated for some time. This gives us much more than the daily supply. Place this manure on the outside of the new heap, and then take a quantity of hot, fermenting, manure from the middle of the old heap, and throw it into the center of the new heap, and then cover it up with the fresh manure. I would put in eight or ten bushels, or as much as will warm up the center of the new heap, and start fermentation. The colder the weather, the more of this hot manure should you take from the old heap—the more the better. Fresh manure should be added to the old heap to fill up the hole made by the removal of the hot manure.

"You draw out a great many loads of manure during the winter," said the Deacon, "and pile it in the field, and I have always thought it a good plan, as you do the work when there is little else to do, and when the ground is frozen."

Yes, this is an improvement on my old plan. I formerly used to turn over the heap of manure in the barn-yard in March, or as soon as fermentation had ceased.

The object of turning the heap is (1st,) to mix the manure and make it of uniform quality; (2d,) to break the lumps and make the manure fine; and (3d,) to lighten up the manure and make it loose, thus letting in the air and inducing a second fermentation. It is a good plan, and well repays for the labor. In doing the work, build up the end and sides of the new heap straight, and keep the top flat. Have an eye on the man doing the work, and see that he breaks up the manure and mixes it thoroughly, and that he *goes to the bottom of the heap.*

My new plan that the Deacon alludes to, is, instead of turning the heap in the yard, to draw the manure from the heap in the yard, and pile it up in another heap in the field where it is to be used. This has all the effects of turning, and at the same time saves a good deal of team-work in the spring.



A, B, Manure Heaps; C, D, E, Ridges, 2½ ft. apart.

The location of the manure-heap in the field deserves some consideration. If the manure is to be used for root-crops or potatoes, and if the land is to be ridged, and the manure put in the ridges, then it will be desirable to put the heap on the headland, or, better still, to make two heaps, one on the headland top of the field, and the other on the headland at the bottom of the field, as shown in the annexed engraving.

We draw the manure with a cart, the horse walking between two of the ridges (D), and the wheels of the cart going in C and E. The manure is pulled out at the back end of the cart into small heaps, about five paces apart.

"That is what I object to with you agricultural writers," said the Doctor; "you say 'about five paces,' and sometimes 'about five paces would mean 4 yards, and sometimes 6 yards; and if you put 10 tons of manure per acre in the one case, you would put 15 tons in the other—which makes quite a difference in the dose."

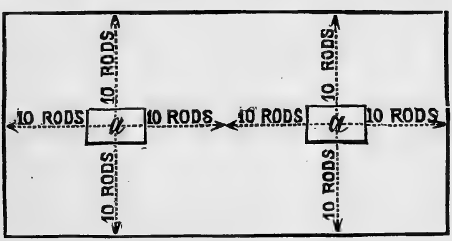
The Doctor is right. Let us figure a little. If your cart holds 20 bushels, and if the manure weighs 75 lbs. to the bushel, and you wish to put on 10 tons of manure per acre, or 1,500 bushels, or 13⅓ cart-loads, then, as there are 43,560 square feet in an acre, you want a bushel of manure to 29 square feet, or say a space 2 yards long, by nearly 5 feet wide.

Now, as our ridges are 2½ feet apart, and as our usual plan is to manure 5 ridges at a time, or 12½ feet wide, a load of 20 bushels of manure will go over a space 46½ feet long, nearly, or say 15½ yards; and so, a load would make 3 heaps, 15½ feet apart, and there would be 6⅔ bushels in each heap.

If the manure is to be spread on the surface of the land, there is no necessity for placing the heap on the headland. You can make the heap or heaps.—"Where most convenient," broke in the Deacon.—"No, not by any means," I replied; "for if that was the rule, the men would certainly put the heap just where it happened to be the least trouble for them to draw and throw off the loads."

The aim should be to put the heap just where it will require the least labor to draw the manure on to the land in the spring.

On what we call "rolling," or hilly land, I would put the heap on the highest land, so that in the spring the horses would be going down hill with the full carts or wagons. Of course, it would be very unwise to adopt this plan if the manure was not

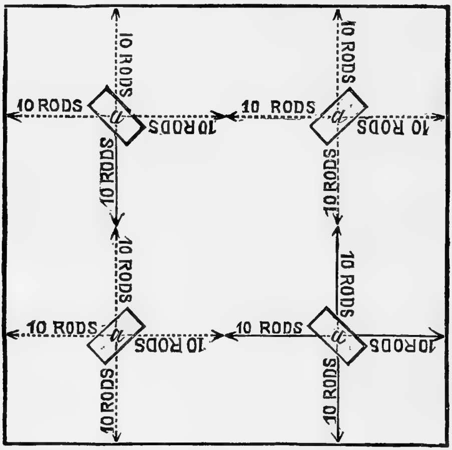


Field, 40x20 *Rods, showing Position of two Heaps of Manure, a, a.*

drawn from the yards until spring, when the land was soft; but I am now speaking of drawing out the manure in the winter, when there is sleighing, or when the ground is frozen. No farmer will object to a little extra labor for the teams in the winter, if it will save work and time in the spring.

If the land is level, then the heap or heaps should be placed where the least distance will have to be traveled in drawing the manure from the heap to the land. If there is only one heap, the best point would be in the center of the field. If two heaps, and the field is longer than it is broad, say 20 rods wide, and 40 rods long, then the heaps should be made as shown on the previous page.

If the field is square, say 40 x 40 rods, and we can have four heaps of manure, then, other things being equal, the best points for the heaps are shown in the annexed figure:



Field, 40x40 *Rods, showing Position of four Heaps of Manure, a. a, a, a.*

Having determined where to make the heaps, the next question is in regard to size. We make one about 8 feet wide and 6 feet high, the length being determined by the quantity of the manure we have to draw. In cold weather, it is well to finish the heap each day as far as you go, so that the sloping side at the end of the heap will not be frozen during the night. Build up the sides square, so that the top of the heap shall be as broad as the bottom. You will have to see that this is done, for the average farm-man, if left to himself, will certainly narrow up the heap like the roof of a house. The reason he does this is that he throws the manure from the load into the center of the heap, and he can not build up the sides straight and square without getting on to the heap occasionally, and placing a layer round the outsides. He should be instructed, too, to break up the lumps, and mix the manure, working it over until it is loose and fine. If there are any frozen masses of manure, place them on the east or south outside, and not in the middle of the heap.

If there is any manure in the sheds, or basements, or cellars, or pig-pens, clean it out, and draw it at once to the pile in the field, and mix it with the manure you are drawing from the heap in the yard.

We generally draw with two teams and three wagons. We have one man to fill the wagon in the yard, and two men to drive and unload. When the man comes back from the field, he places his empty wagon by the side of the heap in the yard, and takes off the horses and puts them to the loaded wagon, and drives to the heap in the field. If we have men and teams enough, we draw with three teams and three wagons. In this case, we put a reliable man at the heap, who helps the driver to unload, and sees that the heap is built properly. The driver helps the man in the yard to load up. In the former plan, we have two teams and three men; in the latter case, we have three teams and five men, and as we have two men loading and unloading, instead of one, we ought to draw out double the quantity of manure in a day. If the weather is cold and windy, we put the blankets on the horses under the harness, so that they will not be chilled while standing at the heap in the yard or field. They will trot back lively with the empty wagon or sleigh, and the work will proceed briskly, and the manure be less exposed to the cold.

"You do not," said the Doctor, "draw the manure on to the heap with a cart, and dump it, as I have seen it done in England?"

I did so a few years ago, and might do so again if I was piling manure in the spring, to be kept over summer for use in the fall. The compression caused by drawing the cart over the manure, has a tendency to exclude the air and thus retard fermentation. In the winter there is certainly no necessity for resorting to any means for checking fermentation. In the spring or summer it may be well to compress the heap a little, but not more, I think, than can be done by the trampling of the workman in spreading the manure on the heap.

"You do not," said the Doctor, "adopt the old-fashioned English plan of keeping your manure in a basin in the barn-yard, and yet I should think it has some advantages."

"I practised it here," said I, "for some years. I plowed and scraped a large hole or basin in the yard four or five feet deep, with a gradual slope at one end for convenience in drawing out the loads—the other sides being much steeper. I also made a tank at the bottom to hold the drainage, and had a pump in it to pump the liquid back on to the heap in dry weather. We threw or wheeled the manure from the stables and pig-pens into this basin, but I did not like the plan, for two reasons: (1,) the manure being spread over so large a surface froze during winter, and (2,) during the spring there was so much water in the basin that it checked fermentation."

Now, instead of spreading it all over the basin, we commenced a small heap on one of the sloping sides of the basin; with a horse and cart we drew to this heap, just as winter set in, every bit of manure that could be found on the premises, and everything that would make manure. When got all together, it made a heap seven or eight feet wide, twenty feet long, and three or four feet high. We then laid planks on the heap, and every day, as the pig-pens, cow and horse stables were cleaned out, the manure was wheeled on to the heap and shaken out and spread about. The heap soon commenced to ferment, and when the cold weather set in, although the sides and some parts of the top froze a little, the inside kept quite warm. Little chimneys were formed in the heap, where the heat and steam escaped. Other parts of the heap would be covered with a thin crust of frozen manure. By taking a few forkfuls of the latter, and placing them on the top of the "chimneys," they checked the escape of steam, and had a tendency to distribute the heat to other parts of the heap. In this way the fermentation became more general throughout all the mass, and not so violent at any one spot.

"But why be at all this trouble?"—For several reasons. First. It saves labor in the end. Two hours' work, in winter, will save three hours' work in the spring. And three hours' work in the spring is worth more than four hours' work in the winter. So that we save half the expense of handling the manure. 2d. When manure is allowed to lie scattered about over a large surface, it is liable to have much of its value washed out by the rain. In a compact heap of this kind, the rain or snow that falls on it is not more than the manure needs to keep it moist enough for fermentation. 3d. There is as much fascination in this fermenting heap of manure as there is in having money in a savings bank. One is continually trying to add to it. Many a cart-load or wheel-barrowful of material will be deposited that would otherwise be allowed to run to waste. 4th. The manure, if turned over in February or March, will be in capital order for applying to root crops; or if your hay and straw contains weed-seeds, the manure will be in good condition to spread as a top-dressing on grass-land early in the spring. This, I think, is better than keeping it in the yards all summer, and then drawing it out on the grass land in September. You gain six months' or a year's time. You get a splendid growth of rich grass, and the red-root seeds will germinate next September just as well as if the manure was drawn out at that time. If the manure is drawn out early in the spring, and spread out immediately, and then harrowed two or three times with a Thomas' smoothing-harrow, there is no danger of its imparting a rank flavor to the grass. I know from repeated trials that when part of a pasture is top-dressed, cows and sheep will keep it much more closely cropped down than the part which has not been manured. The idea to the contrary originated from not spreading the manure evenly.

"But why ferment the manure at all? Why not draw it out fresh from the yards? Does fermentation increase the amount of plant-food in the manure?"—No. But it renders the plant-food in the manure more immediately available. It makes it more soluble. We ferment manure for the same reason that we decompose bone-dust or mineral phosphates with sulphuric acid, and convert them into superphosphate, or for the same reason that we grind our corn and cook the meal. These processes add nothing to the amount of plant-food in the bones or the nutriment in the corn. They only increase its availability. So in fermenting manure. When the liquid and solid excrements from well-fed animals, with the straw necessary to absorb the liquid, are placed in a heap, fermentation sets in and soon effects very important changes in the nature and composition of the materials. The insoluble woody fibre of the straw is decomposed and converted into humic and ulmic acids. These are insoluble; and when manure consists almost wholly of straw or corn stalks, there would be little gained by fermenting it. But when there is a good proportion of manure from well fed animals in the heap, carbonate of ammonia is formed from the nitrogenous compounds in the manure, and this ammonia unites with the humic and ulmic acids and forms humate and ulmate of ammonia. These ammoniacal salts are soluble in water—as the brown color of the drainings of a manure heap sufficiently indicates.

Properly fermented manure, therefore, of good quality, is a much more active and immediately useful fertilizer than fresh, unfermented manure. There need be no loss of ammonia from evaporation, and the manure is far less bulky, and costs far less labor to draw out and spread. The only loss that is likely to occur is from leaching, and this must be specially guarded against.

CHAPTER XXI.

THE MANAGEMENT OF MANURES.—Continued.

WHY DO WE FERMENT MANURE?

However much farmers may differ in regard to the advantages or disadvantages of fermenting manure, I have never met with one who contended that it was good, either in theory or practice, to leave manure for months, scattered over a barn-yard, exposed to the spring and autumn rains, and to the summer's sun and wind. All admit that, if it is necessary to leave manure in the yards, it should be either thrown into a basin, or put into a pile or heap, where it will be compact, and not much exposed.

We did not need the experiments of Dr. Vœlcker to convince us that there was great waste in leaving manure exposed to the leaching action of our heavy rains. We did not know exactly how much we lost, but we knew it must be considerable. No one advocates the practice of exposing manure, and it is of no use to discuss the matter. All will admit that it is unwise and wasteful to allow manure to lie scattered and exposed over the barn-yards any longer than is absolutely necessary.

We should either draw it directly to the field and use it, or we should make it into a compact heap, where it will not receive more rain than is needed to keep it moist.

One reason for piling manure, therefore, is to preserve it from loss, until we wish to use it on the land.

"We all admit that," said the Deacon, "but is there anything actually gained by fermenting it in the heap?"—In one sense, no; but in another, and very important sense, yes. When we cook corn-meal for our little pigs, we add nothing to it. We have no more meal after it is cooked than before. There are no more starch, or oil, or nitrogenous matters in the meal, but we think the pigs can digest the food more readily. And so, in fermenting manure, we add nothing to it; there is no more actual nitrogen, or phosphoric acid, or potash, or any other ingredient after fermentation than there was before, but these ingredients are rendered more soluble, and can be more rapidly taken up by the plants. In this sense, therefore, there is a great gain.

One thing is certain, we do not, in many cases, get anything like as much benefit from our manure as the ingredients it contains would lead us to expect.

Mr. Lawes, on his clayey soil at Rothamsted, England, has grown over thirty crops of wheat, year after year, on the same land. One plot has received 14 tons of barn-yard manure per acre every year, and yet the produce from this plot is no larger, and, in fact, is frequently much less, than from a few hundred pounds of artificial manure containing far less nitrogen.

For nineteen years, 1852 to 1870, some of the plots have received the same manure year after year. The following shows the *average* yield for the nineteen years:

	Wheat per acre.	*Straw per acre.*
Plot 5.—Mixed mineral manure, alone	17 bus.	15 cwt.
" 6.—Mixed mineral manure, and 200 lbs. ammoniacal salts	27 bus.	25 cwt.
" 7.—Mixed mineral manure, and 400 lbs. ammoniacal salts	36 bus.	36 cwt.
" 9.—Mixed mineral manure, and 550 lbs. nitrate of soda	37 bus.	41 cwt.
" 2.—14 tons farm-yard dung	36 bus.	34 cwt.

The 14 tons (31,360 lbs.) of farm-yard manure contained about 8,540 lbs. organic matter, 868 lbs. mineral matter, and 200 lbs. nitrogen. The 400 lbs. of ammoniacal salts, and the 550 lbs. nitrate of soda, each contained 82 lbs. of nitrogen; and it will be seen that this 82 lbs. of nitrogen produced as great an effect as the 200 lbs. of nitrogen in barn-yard manure.

Similar experiments have been made on barley, with even more striking results. The plot dressed with 300 lbs. superphosphate of lime, and 200 lbs. ammoniacal salts per acre, produced as large a crop as 14 tons of farm-yard manure. The average yield of barley for nineteen crops grown on the same land each year was 48 bus. and 28 cwt. of straw per acre on both plots. In other words, 41 lbs. of nitrogen, in ammoniacal salts, produced as great an effect as 200 lbs. of nitrogen in farm-yard manure! During the nineteen years, one plot had received 162,260 lbs. of organic matter, 16,492 lbs. of mineral matter, and 3,800 lbs. of nitrogen; while the other had received only 5,700 lbs. mineral matter, and 779 lbs. of nitrogen—and yet one has produced as large a crop as the other.

Why this difference? It will not do to say that more nitrogen was applied in the farm-yard manure than was needed. Mr. Lawes says: "For some years, an amount of ammonia-salts, containing 82 lbs. of nitrogen, was applied to one series of plots (on barley), but this was found to be too much, the crop generally being too heavy and laid. Yet probably about 200 lbs. of nitrogen was annually supplied in the dung, but with it there was no over-luxuriance, and no more crop, than where 41 lbs. of nitrogen was supplied in the form of ammonia or nitric acid."

It would seem that there can be but one explanation of these accurately-ascertained facts. The nitrogenous matter in the manure is not in an available condition. It is in the manure, but the plants can not take it up until it is decomposed and rendered soluble. Dr. Vœlcker analyzed "perfectly fresh horse-dung," and found that of *free* ammonia there was not more than one pound in 15 tons! And yet these 15 tons contained nitrogen enough to furnish 140 lbs. of ammonia.

"But," it may be asked, "will not this fresh manure decompose in the soil, and furnish ammonia?" In light, sandy soil, I presume it will do so to a considerable extent. We know that clay mixed with manure retards fermentation, but sand mixed with manure accelerates fermentation. This, at any rate, is the case when sand is added in small quantities to a heap of fermenting manure. But I do not suppose it would have the same effect when a small quantity of manure is mixed with a large amount of sand, as is the case when manure is applied to land, and plowed under. At any rate, practical farmers, with almost entire unanimity, think well-rotted manure is better for sandy land than fresh manure.

As to how rapidly, or rather how slowly, manure decomposes in a rather heavy loamy soil, the above experiments of Mr. Lawes afford very conclusive, but at the same time very discouraging evidence. During the 19 years, 3,800 lbs. of nitrogen, and 16,492 lbs. of mineral matter, in the form of farm-yard manure, were applied to an acre of land, and the 19 crops of barley in grain and straw removed only 3,724 lbs. of mineral matter, and 1,064 lbs. of nitrogen. The soil now contains, unless it has drained away, 1,736 lbs. more nitrogen per acre than it did when the experiments commenced. And yet 41 lbs. of nitrogen in an *available condition* is sufficient to produce a good large crop of barley, and 82 lbs. per acre furnished more than the plants could organize.

"Those are very interesting experiments," said the Doctor, "and show why it is that our farmers can afford to pay a higher price for nitrogen and phosphoric acid in superphosphate, and other artificial manures, than for the same amount of nitrogen and phosphoric acid in stable-manure."

We will not discuss this point at present. What I want to ascertain is, whether we can not find some method of making our farm-yard manure more readily available. Piling it up, and letting it ferment, is one method of doing this, though I think other methods will yet be discovered. Possibly it will be found that spreading well-rotted manure on the surface of the land will be one of the most practical and simplest methods of accomplishing this object.

"We pile the manure, therefore," said Charley, "first, because we do not wish it to lie exposed to the rain in the yards, and, second, because fermenting it in the heap renders it more soluble, and otherwise more available for the crops, when applied to the land."

That is it exactly, and another reason for piling manure is, that the fermentation greatly reduces its bulk, and we have less labor to perform in drawing it out and spreading it. Ellwanger & Barry, who draw several thousand loads of stable-manure every year, and pile it up to ferment, tell me that it takes three loads of fresh manure to make one load of rotted manure. This, of course, has reference to bulk, and not weight. Three tons of fresh barn-yard manure, according to the experiments of Dr. Vœlcker, will make about two tons when well rotted. Even this is a great saving of labor, and the rotted manure can be more easily spread, and mixed more thoroughly with the soil—a point of great importance.

"Another reason for fermenting manure," said the Squire, "is the destruction of weed-seeds."

"That is true," said I, "and a very important reason; but I try not to think about this method of killing weed-seeds. It is a great deal better to kill the weeds. There can be no doubt that a fermenting manure-heap will kill many of the weed-seeds, but enough will usually escape to re-seed the land."

It is fortunate, however, that the best means to kill weed-seeds in the manure, are also the best for rendering the manure most efficient. I was talking to John Johnston on this subject a few days ago. He told me how he piled manure in his yards.

"I commence," he said, "where the heap is intended to be, and throw the manure on one side, until the bare ground is reached."

"What is the use of that?" I asked.

"If you do not do so," he replied, "there will be some portion of the manure under the heap that will be so compact that it will not ferment, and the weed-seeds will not be killed."

"You think," said I, "that weed-seeds can be killed in this way?"

"I know they can," he replied," bút the heap must be carefully made, so that it will ferment evenly, and when the pile is turned, the bottom and sides should be thrown into the center of the heap."

LOSS OF AMMONIA BY FERMENTING MANURE.

If you throw a quantity of fresh horse-manure into a loose heap, fermentation proceeds with great rapidity. Much heat is produced, and if the manure is under cover, or there is not rain enough to keep the heap moist, the manure will "fire-fang" and a large proportion of the carbonate of ammonia produced by the fermentation will escape into the atmosphere and be lost.

As I have said before, we use our horse-manure for bedding the store and fattening pigs. We throw the manure every morning and evening, when the stable is cleaned out, into an empty stall near the door of the stable, and there it remains until wanted to bed the pigs. We find it is necessary to remove it frequently, especially in the summer, as fermentation soon sets in, and the escape of the ammonia is detected by its well known pungent smell. Throw this manure into the pig-cellar and let the pigs trample it down, and there is no longer any escape of ammonia. At any rate, I have never perceived any. Litmus paper will detect ammonia in an atmosphere containing only one seventy-five thousandth part of it; and, as Prof. S. W. Johnson once remarked, "It is certain that a healthy nose is not far inferior in delicacy to litmus paper." I feel sure that no ammonia escapes from this horse-manure after it is trampled down by the pigs, although it contains an additional quantity of "potential ammonia" from the liquid and solid droppings of these animals.

Water has a strong attraction for ammonia. One gallon of ice-cold water will absorb 1,150 gallons of ammonia.

If the manure, therefore, is moderately moist, the ammonia is not likely to escape. Furthermore, as Dr. Vœlcker has shown us, during the fermentation of the manure in a heap, ulmic and humic, crenic and aprocrenic acids are produced, and these unite with the ammonia and "fix" it—in other words, they change it from a volatile gas into a non-volatile salt.

If the heap of manure, therefore, is moist enough and large enough, all the evidence goes to show, that there is little or no loss of ammonia. If the centre of the heap gets so hot and so dry that the ammonia is not retained, there is still no necessity for loss.

The sides of the heap are cool and moist, and will retain the carbonate of ammonia, the acids mentioned also coming into play.

The ammonia is much more likely to escape from the top of the heap than from the sides. The heat and steam form little chimneys, and when a fermenting manure-heap is covered with snow, these little chimneys are readily seen. If you think the manure is fermenting too rapidly, and that the ammonia is escaping, trample the manure down firmly about the chimneys, thus closing them up, and if need be, or if convenient, throw more manure on top, or throw on a few pailfuls of water.

It is a good plan, too, where convenient, to cover the heap with soil. I sometimes do this when piling manure in the field, not from fear of losing ammonia, but in order to retain moisture in the heap. With proper precautions, I think we may safely dismiss the idea of any serious loss of ammonia from fermenting manure.

THE WASTE OF MANURE FROM LEACHING.

As we have endeavored to show, there is little danger of losing ammonia by keeping and fermenting manure. But this is not the only question to be considered. We have seen that in 10,000 lbs. of fresh farm-yard manure, there is about 64 lbs. of nitrogen. Of this, about 15 lbs. are soluble, and 49 lbs. insoluble. Of mineral matter, we have in this quantity of manure, 559 lbs., of which 154 lbs. are soluble in water, and 405 lbs. insoluble. If we had a heap of five tons of fermenting manure in a stable, the escape of half an ounce of carbonate of ammonia would make a tremendous smell, and we should at once use means to check the escape of this precious substance. But it will be seen that we have in this five tons of fresh manure, nitrogenous matter, capable of forming over 180 lbs. of carbonate of ammonia, over 42 lbs. of which is in a soluble condition. This may be leached day after day, slowly and imperceptibly, with no heat, or smell, to attract attention.

How often do we see manure lying under the eaves of an unspouted shed or barn, where one of our heavy showers will saturate it in a few minutes, and yet where it will lie for hours, and days, and weeks, until it would seem that a large proportion of its soluble matter would be washed out of it! The loss is unquestionably very great, and would be greater if it were not for the coarse nature of the material, which allows the water to pass through it rapidly and without coming in direct contact with only the outside portions of the particles of hay, straw, etc., of which the manure is largely composed. If the manure was ground up very fine, as it would be when prepared for analysis, the loss of soluble matter would be still more serious. Or, if the manure was first fermented, so that the particles of matter would be more or less decomposed and broken up fine, the rain would wash out a large amount of soluble matter, and prove much more injurious than if the manure was fresh and unfermented.

"That is an argument," said the Deacon, "against your plan of piling and fermenting manure."

"Not at all," I replied; "it is a strong reason for not letting manure lie under the eaves of an unspouted building—especially *good* manure, that is made from rich food. The better the manure, the more it will lose from bad management. I have never recommended any one to pile their manure where it would receive from ten to twenty times as much water as would fall on the surface of the heap."

"But you do recommend piling manure and fermenting it in the open air and keeping the top flat, so that it will catch all the rain, and I think your heaps must sometimes get pretty well soaked."

"Soaking the heap of manure," I replied, "does not wash out any of its soluble matter, *provided* you carry the matter no further than the point of saturation. The water may, and doubtless does, wash out the soluble matter from some portions of the manure, but if the water does not filter through the heap, but is all absorbed by the manure, there is no loss. It is when the water passes through the heap that it runs away with our soluble nitrogenous and mineral matter, and with any ready formed ammonia it may find in the manure."

How to keep cows tied up in the barn, and at the same time save all the urine, is one of the most difficult problems I have to deal with in the management of manure on my farm. The best plan I have yet tried is, to throw horse-manure, or sheep-manure, back of the cows, where it will receive and absorb the urine. The plan works well, but it is a question of labor, and the answer will depend on the arrangement of the buildings. If the horses are kept near the cows, it will be little trouble to throw the horse-litter, every day, under or back of the cows.

In my own case, my cows are kept in a basement, with a tight barn-floor overhead. When this barn-floor is occupied with sheep, we keep them well-bedded with straw, and it is an easy matter to throw this soiled bedding down to the cow-stable below, where it is used to absorb the urine of the cows, and is then wheeled out to the manure-heap in the yard.

At other times, we use dry earth as an absorbent.

CHAPTER XXII.

MANURE ON DAIRY-FARMS.

Farms devoted principally to dairying ought to be richer and more productive than farms largely devoted to the production of grain.

Nearly all the produce of the farm is used to feed the cows, and little is sold but milk, or cheese, or butter.

When butter alone is sold, there ought to be no loss of fertilizing matter—as pure butter or oil contains no nitrogen, phosphoric acid, or potash. It contains nothing but carbonaceous matter, which can be removed from the farm without detriment.

And even in the case of milk, or cheese, the advantage is all on the side of the dairyman, as compared with the grain-grower. A dollar's worth of milk or cheese removes far less nitrogen, phosphoric acid, and potash, than a dollar's worth of wheat or other grain. Five hundred lbs. of cheese contains about 25 lbs. of nitrogen, and 20 lbs. of mineral matter. A cow that would make this amount of cheese would eat not less than six tons of hay, or its equivalent in grass or grain, in a year. And this amount of food, supposing it to be half clover and half ordinary meadow-hay, would contain 240 lbs. of nitrogen and 810 lbs. of mineral matter. In other words, a cow eats 240 lbs. of nitrogen, and 25 lbs. are removed in the cheese, or not quite $10\frac{1}{2}$ per cent, and of mineral matter not quite $2\frac{1}{2}$ per cent is removed. If it takes three acres to produce this amount of food, there will be $8\frac{1}{3}$ lbs. of nitrogen removed by the cheese, per acre, while 30 bushels of wheat would remove in the grain 32 lbs. of nitrogen, and 10 to 15 lbs. in the straw. So that a crop of wheat removes from five to six times as much nitrogen per acre as a crop of cheese; and the removal of mineral matter in cheese is quite insignificant as compared with the amount removed in a crop of wheat or corn. If our grain-growing farmers can keep up the fertility of their land, as they undoubtedly can, the dairymen ought to be making theirs richer and more productive every year.

"All that is quite true," said the Doctor, "and yet from what I have seen and heard, the farms in the dairy districts, do not, as a rule, show any rapid improvement. In fact, we hear it often alleged that the soil is becoming exhausted of phosphates, and that the quantity and quality of the grass is deteriorating."

"There may be some truth in this," said I, "and yet I will hazard the prediction that in no other branch of agriculture shall we witness a more decided improvement during the next twenty-five years than on farms largely devoted to the dairy. Grain-growing farmers, like our friend the Deacon, here, who sells his grain and never brings home a load of manure, and rarely buys even a ton of bran to feed to stock, and who sells more or less hay, must certainly be impoverishing their soils of phosphates much more rapidly than the dairyman who consumes nearly all his produce on the farm, and sells little except milk, butter, cheese, young calves, and old cows."

"Bones had a wonderful effect," said the Doctor, "on the old pastures in the dairy district of Cheshire in England."

"Undoubtedly," I replied, "and so they will here, and so would well-rotted manure. There is nothing in this fact to prove that dairying specially robs the soil of phosphates. It is not phosphates that the dairyman needs so much as richer manure."

"What would you add to the manure to make it richer?" asked the Doctor.

"Nitrogen, phosphoric acid, and potash," I replied.

"But how?" asked the Deacon.

"I suppose," said the Doctor, "by buying guano and the German potash salts."

"That would be a good plan," said I; "but I would do it by buying bran, mill-feed, brewer's-grains, malt-combs, corn-meal, oil-cake, or whatever was best and cheapest in proportion to value. Bran or mill-feed can often be bought at a price at which it will pay to use it freely for manure. A few tons of bran worked into a pile of cow-dung would warm it up and add considerably to its value. It would supply the nitrogen, phosphoric acid, and potash, in which ordinary manure is deficient. In short, it would convert poor manure into rich manure."

"Well, well," exclaimed the Deacon, "I knew you talked of mixing dried-blood and bone-dust with your manure, but I did not think you would advocate anything quite so extravagant as taking good, wholesome bran and spout-feed and throwing it on to your manure-pile."

"Why, Deacon," said I, "we do it every day. I am putting about a ton of spout-feed, malt-combs and corn-meal each week into my manure-pile, and that is the reason why it ferments so readily even in the winter. It converts my poor manure into good, rich, well-decomposed dung, one load of which is worth three loads of your long, strawy manure."

"Do you not wet it and let it ferment before putting it in the pile?"

"No, Deacon," said I, "I feed the bran, malt-combs and corn-meal to the cows, pigs, and sheep, and let them do the mixing. They work it up fine, moisten it, break up the particles, take out the carbonaceous matter, which we do not need for manure, and the cows and sheep and horses mix it up thoroughly with the hay, straw, and corn-stalks, leaving the whole in just the right condition to put into a pile to ferment or to apply directly to the land."

"Oh! I see," said the Deacon, "I did not think you used bran for manure."

"Yes, I do, Deacon," said I, "but I use it for food *first*, and this is precisely what I would urge you and all others to do. I feel sure that our dairymen can well afford to buy more mill-feed, corn-meal, oil-cake, etc., and mix it with their cow-dung—or rather, let the cows do the mixing."

LETTER FROM THE HON. HARRIS LEWIS.

I wrote to the Hon. Harris Lewis, the well-known dairyman of Herkimer Co., N. Y., asking him some questions in regard to making and managing manure on dairy farms. The questions will be understood from the answers. He writes as follows:

"My Friend Harris.—This being the first leisure time I have had since the receipt of your last letter, I devote it to answering your questions:

"1st. I have no manure cellar.

"I bed my cows with dry basswood sawdust, saving all the liquid manure, keeping the cows clean, and the stable odors down to a tolerable degree. This bedding breaks up the tenacity of the cow-manure, rendering it as easy to pulverize and manage as clear horse-manure. I would say it is just lovely to bed cows with dry basswood sawdust. This manure, if left in a large pile, will ferment and burn like horse-manure in about 10 days. Hence I draw it out as made where I desire to use it, leaving it in small heaps, convenient to spread.

"My pigs and calves are bedded with straw, and this is piled and rotted before using.

"I use most of my manure on grass land, and mangels, some on corn and potatoes; but it pays me best, when in proper condition, to apply all I do not need for mangels, on meadow and pasture.

"Forty loads, or about 18 to 20 cords is a homœopathic dose for an acre, and this quantity, or more, applied once in three years to grass land, agrees with it first rate.

"The land where I grow mangels gets about this dose every year.

"I would say that my up-land meadows have been mown twice each year for a great many years.

"I have been using refuse salt from Syracuse, on my mangels, at the rate of about six bushels per acre, applied broadcast in two applications. My hen-manure is pulverized, and sifted through a common coal sieve. The fine I use for dusting the mangels after they have been singled out, and the lumps, if any, are used to warm up the red peppers.

"I have sometimes mixed my hen-manure with dry muck, in the proportion of one bushel of hen-manure to 10 of muck, and received a profit from it too big to tell of, on corn, and on mangels.

"I have sprinkled the refuse salt on my cow-stable floors sometimes, but where all the liquid is saved, I think we have salt enough for most crops.

"I have abandoned the use of plaster on my pastures for the reason that milk produced on green-clover is not so good as that produced on the grasses proper. I use all the wood ashes I can get, on my mangels as a duster, and consider their value greater than the burners do who sell them to me for 15 cts. a bushel. I have never used much lime, and have not received the expected benefits from its use so far. But wood ashes agree with my land as well as manure does. The last question you ask, but one, is this: 'What is the usual plan of managing manure in the dairy districts?' The usual method is to cut holes in the sides of the stable, about every ten feet along the whole length of the barn behind the cows, and pitch the manure out through these holes, under the eaves of the barn, where it remains until too much in the way, when it is drawn out and commonly applied to grass land in lumps as big as your head. This practice is getting out of fashion a little now, but nearly one-half of all the cow-manure made in Herkimer Co. is lost, wasted.

"Your last question, 'What improvement would you suggest,' I answer by saying it is of no use to make any to these men, it would be wasted like their manure.

"The market value of manure in this county is 50 cts. per big load, or about one dollar per cord."

"That is a capital letter," said the Deacon. "It is right to the point, and no nonsense about it."

"He must make a good deal of manure," said the Doctor, "to be able to use 40 loads to the acre on his meadows and pastures once in three years, and the same quantity every year on his field of mangel-wurzel."

"That is precisely what I have been contending for," I replied; "the dairymen *can* make large quantities of manure if they make an effort to do it, and their farms ought to be constantly improving. Two crops of hay on the same meadow, each year, will enable a farmer to keep a large herd of cows, and make a great quantity of manure—and when you have once got the manure, there is no difficulty in keeping up and increasing the productiveness of the land."

HOW TO MAKE MORE AND BETTER MANURE ON DAIRY FARMS.

"You are right," said the Doctor, "in saying that there is no difficulty in keeping up and increasing the productiveness of our dairy farms, when you have once got plenty of manure—but the difficulty is to get a good supply of manure to start with."

This is true, and it is comparatively slow work to bring up a farm, unless you have plenty of capital and can buy all the artificial manure you want. By the free use of artificial manures, you could make a farm very productive in one or two years. But the slower and cheaper method will be the one adopted by most of our young and intelligent dairymen. Few of us are born with silver spoons in our mouths. We have to earn our money before we can spend it, and we are none the worse for the discipline.

Suppose a young man has a farm of 100 acres, devoted principally to dairying. Some of the land lies on a creek or river, while other portions are higher and drier. In the spring of the year, a stream of water runs through a part of the farm from the adjoining hills down to the creek or river. The farm now supports ten head of cows, three horses, half a dozen sheep, and a few pigs. The land is worth $75 per acre, but does not pay the interest on half that sum. It is getting worse instead of better. Weeds are multiplying, and the more valuable grasses are dying out. What is to be done?

In the first place, let it be distinctly understood that the land is *not* exhausted. As I have before said, the productiveness of a farm does not depend so much on the absolute amount of plant-food which the soil contains, as on the amount of plant-food which is immediately available for the use of the plants. An acre of land that produces half a ton of hay, may contain as much plant-food as an acre that produces three tons of hay. In the one case the plant-food is locked up in such a form that the crops cannot absorb it, while in the other it is in an available condition. I have no doubt there are fields on the farm I am alluding to, that contain

3,000 lbs. of nitrogen, and an equal amount of phosphoric acid, per acre, in the first six inches of the surface soil. This is as much nitrogen as is contained in 100 tons of meadow-hay, and more phosphoric acid than is contained in 350 tons of meadow-hay. These are the two ingredients on which the fertility of our farms mainly depend. And yet there are soils containing this quantity of plant-food that do not produce more than half a ton of hay per acre.

In some fields, or parts of fields, the land is wet and the plants cannot take up the food, even while an abundance of it is within reach. The remedy in this case is under-draining. On other fields, the plant-food is locked up in insoluble combinations. In this case we must plow up the soil, pulverize it, and expose it to the oxygen of the atmosphere. We must treat the soil as my mother used to tell me to treat my coffee, when I complained that it was not sweet enough. "I put plenty of sugar in," she said, "and if you will stir it up, the coffee will be sweeter." The sugar lay undissolved at the bottom of the cup; and so it is with many of our soils. There is plenty of plant-food in them, but it needs stirring up. They contain, it may be, 3,000 lbs. of nitrogen, and other plant-food in still greater proportion, and we are only getting a crop that contains 18 lbs. of nitrogen a year, and of this probably the rain supplies 9 lbs. Let us stir up the soil and see if we cannot set 100 lbs. of this 3,000 lbs. of nitrogen free, and get three tons of hay per acre instead of half a ton. There are men who own a large amount of valuable property in vacant city lots, who do not get enough from them to pay their taxes. If they would sell half of them, and put buildings on the other half, they might soon have a handsome income. And so it is with many farmers. They have the elements of 100 tons of hay lying dorment in every acre of their land, while they are content to receive half a ton a year. They have property enough, but it is unproductive, while they pay high taxes for the privilege of holding it, and high wages for the pleasure of boarding two or three hired men.

We have, say, 3,000 lbs. of nitrogen locked up in each acre of our soil, and we get 8 or 10 lbs. every year in rain and dew, and yet, practically, all that we want, to make our farms highly productive, is 100 lbs. of nitrogen per acre per annum. And furthermore, it should be remembered, that to keep our farms rich, after we have once got them rich, it is not necessary to develope this amount of nitrogen from the soil every year. In the case of clover-hay, the entire loss of nitrogen in the animal and in the milk would not exceed 15 per cent, so that, when we feed out

100 lbs. of nitrogen, we have 85 lbs. left in the manure. We want to develope 100 lbs. of nitrogen in the soil, to enable us to raise a good crop to start with, and when this is once done, an annual development of 15 lbs. per acre in addition to the manure, would keep up the productiveness of the soil. Is it not worth while, therefore, to make an earnest effort to get started?—to get 100 lbs. of nitrogen in the most available condition in the soil?

As I said before, this is practically all that is needed to give us large crops. This amount of nitrogen represents about twelve tons of average barn-yard manure—that is to say, twelve tons contains 100 lbs. of nitrogen. But in point of fact it is not in an immediately available condition. It would probably take at least two years before all the nitrogen it contains would be given up to the plants. We want, therefore, in order to give us a good start, 24 tons of barn-yard manure on every acre of land. How to get this is the great problem which our young dairy farmer has to solve. In the grain-growing districts we get it in part by summer-fallowing, and I believe the dairyman might often do the same thing with advantage. A thorough summer-fallow would not only clean the land, but would render some of the latent plant-food available. This will be organized in the next crop, and when the dairyman has once got the plant-food, he has decidedly the advantage over the grain-growing farmer in his ability to retain it. He need not lose over 15 per cent a year of nitrogen, and not one per cent *of the other elements of plant-food.*

The land lying on the borders of the creek could be greatly benefited by cutting surface ditches to let off the water; and later, probably it will be found that a few underdrains can be put in to advantage. These alluvial soils on the borders of creeks and rivers are grand sources of nitrogen and other plant-food. I do not know the fact, but it is quite probable that the meadows which Harris Lewis mows twice a year, are on the banks of the river, and are perhaps flooded in the spring. But, be this as it may, there is a field on the farm I am alluding to, lying on the creek, which now produces a bountiful growth of weeds, rushes, and coarse grasses, which I am sure could easily be made to produce great crops of hay. The creek overflows in the spring, and the water lies on some of the lower parts of the field until it is evaporated. A few ditches would allow all the water to pass off, and this alone would be a great improvement. If the field was flooded in May or June, and thoroughly cultivated and harrowed, the sod would be sufficiently rotted to plow again in August. Then a thorough harrowing, rolling, and cultivating, would make it as mellow as a garden, and it could be seeded down with timothy and other good grasses the last of August, or beginning of September, and produce a good crop of hay the next year. Or, if thought better, it might be sown to rye and seeded down with it. In either case the land would be greatly improved, and would be a productive meadow or pasture for years to come—or until our young dairyman could afford to give it one of Harris Lewis' "homœopathic" doses of 40 loads of good manure per acre. He would then be able to cut two crops of hay a year—and such hay! But we are anticipating.

That stream which runs through the farm in the spring, and then dries up, could be made to irrigate several acres of the land adjoining. This would double, or treble, or quadruple, ("hold on," said the Deacon,) the crops of grass as far as the water reached. The Deacon does not seem to credit this statement; but I have seen wonderful effects produced by such a plan.

What I am endeavoring to show, is, that these and similar means will give us larger crops of hay and grass, and these in turn will enable us to keep more cows, and make more manure, and the manure will enable us to grow larger crops on other portions of the farm.

I am aware that many will object to plowing up old grass land, and I do not wish to be misunderstood on this point. If a farmer has a meadow that will produce two or three tons of hay, or support a cow, to the acre, it would be folly to break it up. It is already doing all, or nearly all, that can be asked or desired. But suppose you have a piece of naturally good land that does not produce a ton of hay per acre, or pasture a cow on three acres, if such land can be plowed without great difficulty, I would break it up as early in the fall as possible, and summer-fallow it thoroughly, and seed it down again, heavily, with grass seeds the next August. If the land does not need draining, it will not forget this treatment for many years, and it will be the farmer's own fault if it ever runs down again.

In this country, where wages are so high, we must raise large crops per acre, or not raise any. Where land is cheap, it may sometimes pay to compel a cow to travel over three or four acres to get her food, but we cannot afford to raise our hay in half ton crops; it costs too much to harvest them. High wages, high taxes, and high-priced land, necessitate high farming; and by high farming, I mean growing large crops every year, and on every portion of the farm; but high wages and *low-priced land* do not necessarily demand high farming. If the land is cheap we can suffer it to lie idle without much loss. But when we *raise* crops, whether on high-priced land or on low-priced land, we must raise good crops, or the expense of cultivating and harvesting them will eat up all the profits. In the dairy districts, I believe land, in proportion to its quality and nearness to market, commands a higher price than land in the grain-growing districts. Hence it follows that high farming should be the aim of the American dairyman.

I am told that there are farms in the dairy districts of this State worth from one hundred to one hundred and fifty dollars per acre, on which a cow to four acres for the year is considered a good average. At a meeting of the Little Falls Farmers' Club, the Hon. Josiah Shull, gave a statement of the receipts and expenses of his farm of 81½ acres. The farm cost $130 per acre. He kept twenty cows, and fatted one for beef. The receipts were as follows:

Twenty cows yielding 8,337 lbs. of cheese, at about 14¼ cents per pound	$1,186.33
Increase on beef cow	40 00
Calves	45.00
Total receipts	$1,271.33

EXPENSES.

Boy, six months and board	$180.00
Man by the year, and board	360.00
Carting milk and manufacturing cheese	215.00
Total cost of labor	$755.00

THE OTHER EXPENSES WERE:

Fertilizers, plants, etc.	$ 18.00
Horse-shoeing and other repairs of farming implements, (which is certainly pretty cheap,)	50.00
Wear and tear of implements	65.00
Average repairs of place and buildings	175.00
Average depreciation and interest on stock	180.00
Insurance	4.00
Incidentals, (also pretty low,)	50.00
	$620.00

Total receipts	$1,271.33.
Total expenses	1,375.00.

This statement, it is said, the Club considered a very fair estimate.

Now, here is a farm costing $10,595, the receipts from which, saying nothing about interest, are less than the expenses. And if you add two cents per pound more to the price of the cheese, the profit would still be only about $50 per year. The trouble is not so much in the low price of cheese, *as in the low product per acre.* I know some grain-growing farmers who have done no better than this for a few years past.

Mr. Shull places the annual depreciation and interest on stock at $180, equal to nearly one-seventh of the total receipts of the farm. It would pay the wages and board of another man for six months.

Can not it be avoided? Good beef is relatively much higher in this State than good cheese. Some of the dairy authorities tell us that cheese is the cheapest animal food in the world, while beef is the dearest. Why, then, should our dairymen confine their attention to the production of the cheapest of farm products, and neglect almost entirely the production of the dearest? If beef is high and cheese low, why not raise more beef? On low-priced land it may be profitable to raise and keep cows solely for the production of cheese, and when the cows are no longer profitable for this purpose, to sacrifice them—to throw them aside as we do a worn-out machine. And in similar circumstances we may be able to keep sheep solely for their wool, but on high-priced land we can not afford to keep sheep merely for their wool. We must adopt a higher system of farming and feeding, and keep sheep that will give us wool, lambs, and mutton. In parts of South America, where land costs nothing, cattle can be kept for their bones, tallow, and hides, but where food is costly we must make better use of it. A cow is a machine for converting vegetable food into veal, butter, cheese, and beef. The first cost of the machine, if a good one, is considerable—say $100. This machine has to be kept running night and day, summer and winter, week days and Sundays. If we were running a steam-flouring mill that could never be allowed to stop, we should be careful to lay in a good supply of coal and also have plenty of grain on hand to grind, so that the mill would never have to run empty. No sensible man would keep up steam merely to run the mill. He would want to grind all the time, and as much as possible; and yet coal is a much cheaper source of power than the hay and corn with which we run our milk-producing machine. How often is the latter allowed to run empty? The machine is running night and day—must run, but is it always running to advantage? Do we furnish fuel enough to enable it to do full work, or only little more than enough to run the machinery?

"What has all this to do with making manure on dairy farms?" asked the Deacon; "you are wandering from the point."

"I hope not; I am trying to show that good feeding will pay better than poor feeding—and better food means better manure."

I estimate that it takes from 15 to 18 lbs. of ordinary hay per day to run this cow-machine, which we have been talking about, even when kept warm and comfortable; and if exposed to cold storms, probably not less than 20 lbs. of hay a day, or its equivalent, and this merely to keep the machine running, without doing any work. It requires this to keep the cow alive, and to prevent her losing flesh. If not supplied with the requisite amount of food for this purpose, she will take enough fat and flesh from her own body to make up the deficiency; and if she cannot get it, the machine will stop—in other words, the cow will die.

We have, then, a machine that costs say $100; that will last on an average eight years; that requires careful management; that must have constant watching, or it will be liable to get out of order, and that requires, merely to keep it running, say 20 lbs. of hay per day. Now, what do we get in return? If we furnish only 20 lbs. of hay per day we get—*nothing* except manure. If we furnish 25 lbs. of hay per day, or its equivalent, we get, say half a pound of cheese per day. If we furnish 30 lbs. we get one pound of cheese per day, or 365 lbs. a year. We may not get the one pound of cheese every day in the year; sometimes the cow, instead of giving milk, is furnishing food for her embryo calf, or storing up fat and flesh; and this fat and flesh will be used by and by to produce milk. But it all comes from the food eaten by the cow; and is equal to one pound of cheese per day for 30 lbs. of hay or its equivalent consumed; 20 lbs. of hay gives us nothing; 25 lbs. of hay gives us half a pound of cheese, or 40 lbs. of cheese from one ton of hay; 30 lbs. gives us one pound, or $66\frac{2}{3}$ lbs. of cheese from one ton of hay; 35 lbs. gives us $1\frac{1}{2}$ lbs., or $85\frac{5}{7}$ lbs. of cheese to one ton of hay; 40 lbs. gives us 2 lbs. of cheese, or 100 lbs. of cheese from one ton of hay; 45 lbs. gives us $2\frac{1}{2}$ lbs. of cheese, or 111 lbs. of cheese from one ton of hay; 50 lbs. gives us 3 lbs. of cheese, or 120 lbs. of cheese from one ton of hay.

On this basis, one ton of hay, *in excess of the amount required to keep up the animal heat and sustain the vital functions*, gives us 200 lbs. of cheese. The point I wish to illustrate by these figures, which are of course hypothetical, is, that it is exceedingly desirable to get animals that will eat, digest, and assimilate a large amount of food, over and above that required to keep up the heat of the body and sustain the vital functions. When a cow eats only 25 lbs. of hay a day, it requires one ton of hay to produce 40 lbs. of cheese. But if we could induce her to eat, digest, and assimilate 50 lbs. a day, one ton would produce 120 lbs. of cheese. If a cow eats 33 lbs. of hay per day, or its equivalent in grass, it will require four acres of land, with a productive capacity equal to $1\frac{1}{2}$ tons of hay per acre, to keep her a year. Such a cow, according to the figures given above, will produce $401\frac{1}{2}$ lbs. of cheese a year, or its equivalent in growth. A farm of 80 acres, on this basis, would support 20 cows, yielding, say 8,000 lbs. of cheese. Increase the productive power of the farm one half, (I hope the Deacon has not gone to sleep), and keep 20 cows that will eat half as much again food, and we should then get 21,600 lbs. of cheese. If cheese is worth 15 cents per lb., a farm of 80 acres, producing 1½ tons of hay, or its equivalent, per acre, and supporting 20 cows, would give us a gross return of $1,204.50. The same farm so improved as to produce 2¼ tons of hay or its equivalent, per acre—fed to 20 cows *capable of eating, digesting, and assimilating it*—would give a gross return of $3,240.

In presenting these figures, I hope you will not think me a visionary. I do not think it is possible to get a cow to produce 3 lbs. of cheese a day throughout the whole year. But I do think it quite possible to so breed and feed a cow that she will produce 3 lbs. of cheese per day, *or its equivalent* in veal, flesh, or fat. We frequently have cows that produce 3 lbs. of cheese a day for several weeks; and a cow *can* be so fed that she will produce 3 lbs. of cheese a day without losing weight. And if she can extract this amount of matter out of the food for a part of the year, why can not she do so for the whole year? Are the powers of digestion weaker in the fall and winter than in spring and summer? If not, we unquestionably sustain great loss by allowing this digestive power to run to waste. This digestive power costs us 20 lbs. of hay a day. We can ill afford to let it lie dormant. But the Deacon will tell me that the cows are allowed all the food they will eat, winter and summer. Then we must, if they have digestive power to spare, endeavor to persaude them to eat more. If they eat as much hay or grass as their stomachs are capable of holding, we must endeavor to give them richer hay or grass. Not one farmer in a thousand seems to appreciate the advantage of having hay or grass containing a high percentage of nutriment. I have endeavored to show that a cow eating six tons of hay, or its equivalent, in a year, would produce 400 lbs. of cheese, worth $60. While a cow capable of eating, digesting, and turning to good account, nine tons of hay, or its equivalent, would produce 1,090 lbs. of cheese, or its equivalent in other products, worth $162.

"I am sorry to interrupt the gentleman," said the Deacon with mock gravity.

"Then pray don't," said I; "I will not detain you long, and the subject is one which ought to interest you and every other farmer who keeps his cows on poor grass in summer, and corn-stalks and straw in winter."

I was going to say, when the Deacon interrupted me, that the stomach of a cow may not allow her to eat nine tons of hay a year, but it will allow her to eat six tons; and if these six tons contain as much nutriment as the nine tons, what is the real difference in its value? Ordinarily we should probably estimate the one at $10 per ton, and the other at $15. But according to the above figures, one is worth $10 per ton and the other $27. To get rich grass, therefore, should be the aim of the American dairyman. I hope the Deacon begins to see what connection this has with a large pile of rich manure.

I do not mean merely a heavy growth of grass, but grass containing a high percentage of nutriment. Our long winters and heavy snows are a great advantage to us in this respect. Our grass in the spring, after its long rest, ought to start up like asparagus, and, under the organizing influence of our clear skies, and powerful sun, ought to be exceedingly nutritious. Comparatively few farmers, however, live up to their privileges in this respect. Our climate is better than our farming, the sun richer than our neglected soil. England may be able to produce more grass per acre in a year than we can, but we ought to produce richer grass, and, consequently, more cheese to a cow. And I believe, in fact, that such is often the case. The English dairyman has the advantage of a longer season of growth. We have a shorter season but a brighter sun, and if we do not have richer grass it is due to the want of draining, clean culture, and manuring. The object of American dairymen should be, not only to obtain more grass per acre, but to increase its nutriment in a given bulk. If we could increase it one-half, making six tons equal to nine tons, we have shown that it is nearly three times as valuable. Whether this can be done, I have not now time to consider; but at any rate if your land produces as many weeds as do some fields on my farm, not to say the Deacon's, and if the plant-food that these weeds absorb, could be organized by nutritious grasses, this alone would do a good deal towards accomplishing the object. Whether this can be done or not, we want cows that can eat and turn to good account as much food per annum as is contained in nine tons of ordinary meadow-hay; and we want this nutriment in a bulk not exceeding six tons of hay. *If possible*, we should get this amount of nutriment in grass or hay. But if we can not do this, we must *feed enough concentrated food* to bring it up to the desired standard.

"But will it pay?" asked the Deacon; "I have not much faith in buying feed. A farmer ought to raise everything he feeds out."

"As a rule, this may be true," I replied, "but there are many exceptions. I am trying to show that it will often pay a dairyman well to buy feed rich in nitrogen and phosphates, so as to make rich manure, and give him a start. After he gets his land rich, there is little difficulty in keeping up its productiveness

"Now, I have said—and the figures, if anything, are too low—that if a cow, eating six tons of hay, or its equivalent, a year, produces 400 lbs. of cheese, a cow capable of eating, digesting, and turning to good account nine tons of hay, or its equivalent, a year, would produce 1,090 lbs. of cheese, or its equivalent in other products."

I would like to say much more on this subject, but I hope enough has been said to show that there is great advantage in feeding rich food, even so far as the production of milk or beef is concerned; and if this is the case, then there is no difficulty in making rich manure on a dairy-farm.

And I am delighted to know that many farmers in the dairy districts are purchasing more and more bran and meal every year. Taking milk, and beef, and manure all into the account, I feel sure that it will be found highly profitable; but you must have good cows—cows that can turn their extra food to good account.

This is not the place to discuss the merits of the different breeds of cows. All I wish to show is, that to make better manure, we must use richer food; and to feed this to advantage, we must have animals that can turn a large amount of food, over and above the amount required to sustain the vital functions, into milk, flesh, etc.

"You do not think," said the Deacon, "that a well-bred cow makes any richer manure than a common cow?"

Of course not; but to make rich manure, we must feed well; and we can not afford to feed well unless we have good animals.

HOW TO SAVE AND APPLY MANURE ON A DAIRY-FARM.

We can not go into details on this subject. The truth is, there are several good methods of saving manure, and which is best depends entirely on circumstances. The real point is to save the urine, and keep the cow-stable clean and sweet. There are three prominent methods adopted:

1st. To throw all the liquid and solid excrements into a manure-cellar underneath the cow-stable. In this cellar, dry swamp-muck, dry earth, or other absorbent material, is mixed with the manure in sufficient quantity to keep down offensive odors. A little dry earth or muck is also used in the stable, scattering it twice a day in the gutters and under the hind legs of the cows. Where this is carried out, it has many and decided advantages.

2d. To wheel or throw out the solid parts of the manure, and to have a drain for carrying the liquid into a tank, where it can be pumped on to the heap of manure in the yard. Where many horses or sheep are kept, and only a few cows, this plan can often be used to advantage, as the heap of manure in the yard, consisting of horse-manure, sheep-manure, and a small portion of cow-dung, will be able to absorb all the urine of the cows.

3d. To use sufficient bedding to absorb all the urine in the stable. In my own case, as I have said before, we usually chaff all our straw and stalks. The orts are used for bedding, and we also use a little dry earth—or, to be more exact, I use it when I attend to the matter myself, but have always found more or less trouble in getting the work done properly, unless I give it personal attention. To use "dirt" to keep the stable clean, is not a popular plan in this neighborhood. Where there is an abundance of straw, and especially if cut into chaff, the easiest way to keep the stable clean, and the cows comfortable, is to use enough of this chaffed straw to absorb all the liquid. Clean out the stable twice a day, and wheel the manure directly to the heap, and spread it.

In regard to the application of manure on a dairy-farm, we have seen what Harris Lewis does with his. I also wrote to T. L. Harison, Esq., of St. Lawrence Co., N. Y.; and knowing that he is not only a very intelligent farmer and breeder, but also one of our best agricultural writers, I asked him if he had written anything on the subject of manures.

"St. Lawrence Co.," said the Deacon, "produces capital grass, oats, and barley, but is, I should think, too far north for winter wheat; but what did Mr. Harison say?"—Here is his letter:

"I never wrote anything about manure. Catch me at it! Nor do I know anything about the management of barn-yard manure worth telling. My own practice is dictated quite as much by convenience as by considerations of economy."

"Good," said the Deacon; "he writes like a sensible man."

"My rotation," he continues, "is such that the bulk of the manure made is applied to *one crop;* that is, to my hoed crops, corn, potatoes, and roots, in the second year.

"The manure from the stables is thrown or wheeled out under the sheds adjoining, and as fast as it becomes so large a quantity as to be in the way, or whenever there is an opportunity, it is hauled out to the field, where it is to be used, and put in large piles. It is turned once, if possible, in the spring, and then spread

"The quantity applied, is, as near as may be, 25 loads per acre; but as we use a great deal of straw, we haul out 30 loads, and estimate that in the spring it will be about 25 loads.

"If we have any more (and occasionally we have 100 loads over), we pile it near the barn, and turn it once or twice during the summer, and use it as seems most profitable—sometimes to top-dress an old grass-field, that for some reason we prefer not to break for another year. Sometimes it goes on a piece of fall wheat, and sometimes is kept over for a barley field the following spring, and harrowed in just before sowing.

"I should spread the manure as it comes from the sheds, instead of piling it, but the great quantity of snow we usually have, has always seemed to be an insuperable obstacle. It is an advantage to pile it, and to give it one turning, but, on the other hand, the piles made in cold weather freeze through, and they take a provokingly long time to thaw out in the spring. I never found manure *piled* out of doors to get too much water from rain.

"I have given up using gypsum, except a little in the stables, because the clover grows too strong without it, and so long as this is the case, I do not need gypsum. But I sometimes have a piece of oats or barley that stands still, and looks sick, and a dose of gypsum helps it very much."

"That is a fact worth remembering," said the Deacon.

"I use some superphosphate," continues Mr. Harison, "and some ground bones on my turnips. We also use superphosphate on oats, barley, and wheat (about 200 lbs. per acre), and find it pays. Last year, our estimate was, on 10 acres of oats, comparing with a strip in the middle, left for the purpose, that the 200 lbs. of superphosphate increased the crop 15 bushels per acre, and gave a gain in quality. It was the "Manhattan," which has about three per cent ammonia, and seven to eight per cent soluble phosphoric acid.

"My rotation, which I stick to as close as I can, is: 1, oats; 2, corn, and potatoes, and roots; 3, barley or spring wheat; 4, 5, and 6, grass (clover or timothy, with a little mixture occasionally).

"I am trying to get to 4, fall wheat, but it is mighty risky."

"That is a very sensible letter," said the Deacon; "but it is evident that he raises more grain than I supposed was generally the case in the dairy districts; and the fact that his clover is so heavy that he does not need plaster, indicates that his land is rich."

It merely confirms what I have said all along, and that is, that the dairymen, if they will feed their animals liberally, and cultivate their soil thoroughly, can soon have productive farms. There are very few of us in this section who can make manure enough to give all our corn, potatoes, and roots, 25 loads of rotted manure per acre, and have some to spare.

In the spring of 1877, Mr. Harison wrote: "I have been hauling out manure all winter as fast as made, and putting it on the land. At first we spread it; but when deep snows came, we put it in small heaps. The field looks as if there had been a grain crop on it left uncut."

"That last remark," said the Doctor, "indicates that the manure looks more like straw than well-rotted dung, and is an argument in favor of your plan of piling the manure in the yard or field, instead of spreading it on the land, or putting it in small heaps."

CHAPTER XXIII.

MANAGEMENT OF MANURES ON GRAIN-FARMS.

"I am surprised to find," said the Deacon, "that Mr. Harison, living as he does in the great grass and dairy district of this State, should raise so much grain. He has nearly as large a proportion of his land under the plow as some of the best wheat-growers of Western New York."

This remark of the Deacon is right to the point. The truth is, that some of our best wheat-growers are plowing less land, and are raising more grass, and keeping more stock; and some of the dairymen, though not keeping less stock, are plowing more land. The better farmers of both sections are approaching each other.

At all events, it is certain that the wheat-growers will keep more stock. I wrote to the Hon. Geo. Geddes, of Onondaga Co., N. Y., well known as a large wheat-grower, and as a life-long advocate of keeping up the fertility of our farms by growing clover. He replies as follows:

"I regret that I have not time to give your letter the consideration it deserves. The subject you have undertaken is truly a difficult one. The circumstances of a grain-raiser and a dairyman are so unlike, that their views in regard to the treatment of the manure produced on the farm would vary as greatly as the lines of farming they follow.

"The grain-grower has straw in excess; he tries hard to get it into such form that he can draw it to his fields, and get it at work, at the least cost in labor. So he covers his barn-yards deep with straw, after each snow-storm, and gets his cattle, sheep, and horses, to trample it under foot; and he makes his pigs convert all he can into such form that it will do to apply it to his pastures, etc., in winter or early spring.

"A load of such manure is large, perhaps, but of no very great value, as compared with well-rotted stable-manure from grain-fed horses; but it is as good as much that I have seen drawn from city stables, and carried far, to restore the worn-out hay-fields on the shores of the North River—in fact, quite like it.

"The dairyman, generally, has but little straw, and his manure is mostly dung of cows, worth much more, per cord, than the straw-litter of the grain-growers.

"The grain-grower will want no sheds for keeping off the rain, but, rather, he will desire more water than will fall on an open yard. The milkman will wish to protect his cow-dung from all rains, or even snows; so he is a great advocate of manure-sheds. These two classes of farmers will adopt quite unlike methods of applying their manure to crops.

"I have cited these two classes of farmers, simply to show the difficulty of making any universal laws in regard to the treatment and use of barn-yard manure. * * *

"I think you and I are fully agreed in regard to the farm being the true source of the manure that is to make the land grow better with use, and still produce crops—perhaps you will go with me so far as to say, the greater the crops, the more manure they will make—and the more manure, the larger the crops.

"Now, I object to any special farming, when applied to a whole great division of country, such as merely raising grain, or devoted entirely to dairying.

"I saw at Rome, N. Y., these two leading branches of New York farming united on the Huntington tract of 1,300 acres. Three or four farms (I forget which) had separate and distinct management, conducted by different families, but each had a dairy combined with the raising of large crops of grain, such as wheat, corn, oats, etc. These grain-crops, with suitable areas of meadow and pasture, sustained the dairy, and the cows converted much of the grain, and all of the forage, into manure. Thus was combined, to mutual advantage, these two important branches of New York farming. Wheat and cheese to sell, and constant improvement in crops.

"In our own case, sheep have been combined with grain-raising. So we have sold wool, wheat, and barley, and, in all my life, not five tons of hay. Clover, you know, has been our great forage-crop. We have wintered our sheep mostly on clover-hay, having some timothy mixed with it, that was necessarily cut (to make into hay with the medium, or early clover,) when it was but grass. We have fed such hay to our cows and horses, and have usually worked into manure the corn-stalks of about 20 acres of good corn, each winter, and we have worked all the straw into shape to apply as manure that we could, spreading it thickly on pastures and such other fields as were convenient. Some straw we have sold, mostly to paper-makers."

"That," said the Deacon, "is good, old-fashioned farming. Plenty of straw for bedding, and good clover and timothy-hay for feed, with wool, wheat, and barley to sell. No talk about oil-cake, malt-combs, and mangels; nothing about superphosphate, guano, or swamp-muck."

Mr. Geddes and Mr. Johnston are both representative farmers; both are large wheat-growers; both keep their land clean and thoroughly cultivated; both use gypsum freely; both raise large crops of clover and timothy; both keep sheep, and yet they represent two entirely different systems of farming. One is the great advocate of clover; the other is the great advocate of manure.

I once wrote to Mr. Geddes, asking his opinion as to the best time to plow under clover for wheat. He replied as follows:

"Plow under the clover when it is at full growth. But your question can much better be answered at the end of a long, free talk, which can best be had here. I have many times asked you to come here, not to see fine farming, for we have none to show, but to see land that has been used to test the effects of clover for nearly 70 years. On the ground, I could talk to a willing auditor long, if not wisely. I am getting tired of being misunderstood, and of having my statements doubted when I talk about clover as the great renovator of land. You preach agricultural truth, and the facts you would gather in this neighborhood are worth your knowing, and worth giving to the world. So come here and gather some facts about clover. All that I shall try to prove to you is, that the fact that clover and plaster are by far the cheapest manures that can be had for our lands, has been demonstrated by many farmers beyond a doubt—so much cheaper than barn-yard manure that the mere loading of and spreading costs more than the plaster and clover. Do not quote me as saying this, but come and see the farms hereabouts, and talk with our farmers."

Of course I went, and had a capital time. Mr. Geddes has a magnificent farm of about 400 acres, some four miles from Syracuse. It is in high condition, and is continually improving, and this is due to growing large and frequent crops of clover, and *to good, deep plowing, and clean and thorough culture.*

We drove round among the farmers. "Here is a man," said Mr. G., "who run in debt $45 per acre for his farm. He has educated his family, paid off his debt, and reports his net profits at from $2,000 to $2,500 a year on a farm of 90 acres; and this is due to clover. You see he is building a new barn, and that does not look as though his land was running down under the system." The next farmer we came to was also putting up a new barn, and another farmer was enlarging an old one. "Now, these farmers have never paid a dollar for manure of any kind except plaster, and their lands certainly do not deteriorate."

From Syracuse, I went to Geneva, to see our old friend John Johnston. "Why did you not tell me you were coming?" he said. "I would have met you at the cars. But I am right glad to see you. I want to show you my wheat, where I put on 250 lbs. of guano per acre last fall. People here don't know that I used it, and you must not mention it. It is grand."

I do not know that I ever saw a finer piece of wheat. It was the Diehl variety, sown 14th September, at the rate of 1¼ bushels per acre. It was quite thick enough. One breadth of the drill was sown at the rate of two bushels per acre. This is earlier. "But," said Mr. J., "the other will have larger heads, and will yield more." After examining the wheat, we went to look at the piles of muck and manure in the barn-yard, and from these to a splendid crop of timothy. "It will go 2½ tons of hay per acre," said Mr. J., "and now look at this adjoining field. It is just as good land naturally, and there is merely a fence between, and yet the grass and clover are so poor as hardly to be worth cutting."

"What makes the difference?" I asked.

Mr. Johnston, emphatically, "Manure."

The poor field did not belong to him!

Mr. Johnston's farm was originally a cold, wet, clayey soil. Mr. Geddes' land did not need draining, or very little. Of course, land that needs draining, is richer after it is drained, than land that is naturally drained. And though Mr. Johnston was always a good farmer, yet he says he "never made money until he commenced to drain." The accumulated fertility in the land could then be made available by good tillage, and from that day to this, his land has been growing richer and richer. And, in fact, the same is true of Mr. Geddes' farm. It is richer land to-day than when first plowed, while there is one field that for seventy years has had no manure applied to it, except plaster. How is this to be explained? Mr. Geddes would say it was due to clover and plaster. But this does not fully satisfy those who claim, (and truly), that "always taking out of the meal-tub and never putting in, soon comes to the bottom." The clover can add nothing to the land, that it did not get from the soil, except organic matter obtained from the atmosphere, and the plaster furnishes little or nothing except lime and sulphuric acid. There are all the other ingredients of plant-food to be accounted for—phosphoric acid, potash, soda, magnesia, etc. A crop of clover, or corn, or wheat, or barley, or oats, will not come to perfection unless every one of these elements is present in the soil in an available condition. Mr. Geddes has not furnished a single ounce of any one of them.

"Where do they come from?"

I answer, *from the soil itself.* There is probably enough of these elements in the soil to last ten thousand years; and if we return to the soil all the straw, chaff, and bran, and sell nothing but fine flour, meat, butter, etc., there is probably enough to last a million years, and you and I need not trouble ourselves with speculations as to what will happen after that time. Nearly all our soils are practically inexhaustible. But of course these elements are not in an available condition. If they were, the rains would wash them all into the ocean. They are rendered available by a kind of fermentation. A manure-heap packed as hard and solid as a rock would not decay; but break it up, make it fine, turn it occasionally so as to expose it to the atmosphere, and with the proper degree of moisture and heat it will ferment rapidly, and all its elements will soon become available food for plants. Nothing has been created by the process. It was all there. We have simply made it *available.* So it is with the soil. Break it up, make it fine, turn it occasionally, expose it to the atmosphere, and the elements it contains become available.

I do not think that Mr. Geddes' land is any better, naturally, than yours or mine. We can all raise fair crops by cultivating the land thoroughly, and by never allowing a weed to grow. On Mr. Lawes' experimental wheat-field, the plot that has never received a particle of manure, produces *every year* an average of about 15 bushels per acre. And the whole crop is removed—grain, straw, and chaff. Nothing is returned. And that the land is not remarkably rich, is evident from the fact that some of the farms in the neighborhood, produce, under the ordinary system of management, but little more wheat, once in four or five years than is raised *every year* on this experimental plot without any manure.

Why? Because these farmers do not half work their land, and the manure they make is little better than rotten straw. Mr. Lawes' wheat-field is plowed twice every year, and when I was there, the crop was hand-hoed two or three times in the spring. Not a weed is suffered to grow. And this is all there is to it.

Now, of course, instead of raising 15 bushels of wheat every year, it is a good deal better to raise a crop of 30 bushels every other year, and still better to raise 45 bushels every third year. And it is here that clover comes to our aid. It will enable us to do this very thing, and the land runs no greater risk of exhaustion than Mr. Lawes' unmanured wheat crop.

Mr. Geddes and I do not differ as much as you suppose. In fact, I do not believe that we differ at all. He has for years been an earnest advocate for growing clover as a renovating crop. He thinks it by far the cheapest manure that can be obtained in this section. I agree with him most fully in all these particulars. He formed his opinion from experience and observation. I derived mine from the Rothamsted experiments. And the more I see of practical farming, the more am I satisfied of their truth. Clover is, unquestionably, the great renovating crop of American agriculture. A crop of clover, equal to two tons of hay, when plowed under, will furnish more ammonia to the soil than twenty tons of straw-made manure, drawn out fresh and wet in the spring, or than twelve tons of our ordinary barn-yard manure. No wonder Mr. Geddes and other intelligent farmers recommend plowing under clover as manure. I differ from them in no respect except this: that it is not absolutely essential to plow clover under in the green state in order to get its fertilizing effect; but, if made into hay, and this hay is fed to animals, and all the manure carefully saved, and returned to the land, there need be comparatively little loss. The animals will seldom take out more than from five to ten per cent of all the nitrogen furnished in the food—and less still of mineral matter. I advocate growing all the clover you possibly can—so does Mr. Geddes. He says, plow it under for manure. So say I—unless you can make more from feeding out the clover-hay, than will pay you for waiting a year, and for cutting and curing the clover and drawing back the manure. If you plow it under, you are sure of it. There is no loss. In feeding it out, you may lose more or less from leaching, and injurious fermentation. But, of course, you need not lose anything, except the little that is retained in the flesh, or wool, or milk, of the animals. As things *are* on many farms, it is perhaps best to plow under the clover for manure at once. As things ought to be, it is a most wasteful practice. If you know how to feed out the hay to advantage, and take pains to save the manure (and to add to its value by feeding oil-cake, bran, etc., with it), it is far better to mow your clover, once for hay, and once for seed, than to plow it under. Buy oil-cake and bran with the money got from the seed, and growing clover-seed will not injure the land.

I am glad to hear that Mr. Geddes occasionally sells straw. I once sold 15 tons of straw to the paper-makers for $150, they drawing it themselves, and some of my neighbors criticised me severely for doing so. It is not considered an orthodox practice. I do not advocate selling straw as a rule; but, if you have more than you can use to advantage, and it is bringing a good price, sell part of the straw and buy bran, oil-cake, etc., with the money. To feed nothing but straw to stock is poor economy; and to rot it down for manure is no better. Straw itself is not worth $3.00 a ton for manure; and as one ton of straw, spread in an open yard to rot, will make, in spring, about four tons of so-called manure, and if it costs 50 cents a ton to draw out and spread it, the straw, even at this comparatively high estimate of its value, nets you, when fed out alone, or rotted down, only $1.00 a ton.

I had about 30 tons of straw. Fed out alone or rotted down it would make 120 tons of manure. After deducting the expense of hauling, and spreading, it nets me on the land, $30. Now sell half the straw for $150, and buy three tons of oil-cake to feed out with the other half, and you would have about seventy tons of manure. The manure from the fifteen tons of straw is worth, say $45, and from the three tons of oil-cake, $60, or $105. It will cost $35 to draw and spread it, and will thus net on the land, $70. So far as the manure question is concerned, therefore, it is far better to sell half your straw, and buy oil-cake with the money, than to feed it out alone—and I think it is also far better for the stock. Of course, it would be better for the farm, not to sell any of the straw, and to buy six tons of oil-cake to feed out with it;

but those of us who are short of capital, must be content to bring up our land by slow degrees.

"I am at a loss to understand," wrote Mr. Geddes, "what you mean, when you say that a ton of straw will make, in the spring of the year, four tons of so-called manure. If you had said that four tons of straw would make one ton of manure, I should have thought nothing of it. But how you can turn one ton of straw into four tons of anything that anybody will call manure, I do not see. In a conversation I had with Hon. Lewis F. Allen, of Black Rock, more than a year ago, he told me that he had enquired of the man who furnished hay for feeding cattle at the Central Yards, in Buffalo, as to the loads of manure he sold, and though I can not now say the exact quantity to a ton of hay, I remember that it was very little—far less than I had before supposed. Please explain this straw-manure matter."

Boussingault, the great French chemist-farmer, repeatedly analyzed the manure from his barn-yard. "The animals which had produced this dung, were 30 horses, 30 oxen, and from 10 to 20 pigs. The absolute quantity of moisture was ascertained, by first drying in the air a considerable weight of dung, and after pounding, continuing and completing, the drying of a given quantity." No one can doubt the accuracy of the results. The dung made in the

Winter	of	1837–8,	contained	79.6	per	cent	of	water.
"	"	1838–9,	"	77.8	"	"	"	"
Autumn	"	1839,	"	80.4	"	"	"	"

Fresh solid cow-dung contains, according to the same authority, 90 per cent of water.

I have frequently seen manure drawn out in the spring, that had not been decomposed at all, and with more or less snow among it, and with water dripping from the wagon, while it was being loaded. It was, in fact, straw saturated with water, and discolored by the droppings of animals. Now, how much of such manure would a ton of dry straw make? If we should take 20 lbs. of straw, trample it down, and from time to time sprinkle it with water and snow, until we had got on 80 lbs., and then put on 20 lbs. more straw, and 80 lbs. more water, and keep on until we had used up a ton of straw, how much "so-called manure," should we have to draw out?

20 lbs. of straw, and 80 lbs. water=100 lbs. so-called manure.
2,000 lbs. of straw, and 8,000 lbs. water=10,000 lbs. so-called manure.

In other words, we get five tons of such manure from one ton of straw. This is, perhaps, an extreme case, but there can be little doubt, that a ton of straw, trampled down by cattle, and sheep, in an open barn-yard, exposed to snow and rain, would weigh four tons when drawn out wet in the spring.

Yes, it is quite an argument in favor of manure cellars. I have always had a prejudice against them—probably, because the first one I saw was badly managed. There is, however, no necessity, even in an ordinary open barn-yard, with more or less sheds and stables, of having so much water in the manure when drawn out. The real point of my remarks, which so surprised Mr. Geddes, was this: We have to draw out so much water with our manure, under any circumstances, that we should try to have it as rich as possible. It is certainly true, that, *if* the manure from a ton of straw is worth $3, that from a ton of clover-hay, is worth $10. And it costs no more to draw out and spread the one than the other. I have never yet found a farmer who would believe that a ton of clover-hay, rotted down in the barn-yard, would make three or four tons of manure; but he would readily assent to the proposition, that it took four or five tons of green-clover to make a ton of hay; and that if these four or five tons of green-clover were rotted in the yard, it would make three or four tons of manure. And yet, the only difference between the green-clover and the hay, is, that the latter has lost some 60 or 70 per cent of water in curing. Add that amount of water to the hay, and it will make as much manure as the green-clover from which the hay was made.

GYPSUM AND CLOVER AS MANURE.

A good farmer came in while we were talking. "Nothing like plaster and clover," he said, "for keeping up a wheat-farm." And you will find this the general opinion of nearly all American wheat-growers. It must be accepted as a fact. But the deductions drawn from the fact are as various as they are numerous.

Let us look first at the fact. And, if you like, we will take my own farm as an example. About 60 years ago, it was covered with the primeval forest. The trees, on the higher and drier land, were first cut down, and many of them burnt on the land. Wheat was sown among the stumps. The crop varied in different years, from 10 to 30 bushels per acre. When 30 bushels were grown, the fact was remembered. When 10 bushels only were grown, little was said about it in after years, until now there is a general impression that our wheat crops were formerly much larger per acre than now. I doubt it; but we will not discuss the point. One thing is certain, the land would produce good crops of clover; and when this clover was plowed under for manure, we got better crops of wheat afterwards. This was the rule. Later, we commenced to use gypsum as a top-dressing on clover. The effect was often wonderful. Farmers will tell you that they sowed 200 lbs. of plaster per acre, on their young clover, in the spring, and it *doubled the crop.* This statement expresses an agricultural, and not an arithmetical fact. We do not know that the crop on the plastered portion was twice as heavy as on the unplastered. We know that it was larger, and more luxuriant. There was a greater, and more vigorous growth. And this extra growth was caused by the small top-dressing of powdered gypsum rock. It was a great fact in agriculture. I will call it fact, No. 1.

Then, when the clover was turned under, we usually got good wheat. This is fact, No. 2. On these two facts, hang many of our agricultural theories. We may state these facts in many ways. Still, it all comes to this: Clover is good for wheat; plaster is good for clover.

There is another fact, which is a matter of general observation and remark. You rarely find a good farmer who does not pay special attention to his clover-crop. When I was riding with Mr. Geddes, among the farmers of Onondaga County, on passing a farm where everything looked thrifty—good fences, good buildings, good garden, good stock, and the land clean and in good condition—I would ask who lived there, or some other question. No matter what. The answer was always the same. "Oh! he is another of our clover men." We will call this fact, No. 3.

And when, a year afterwards, Mr. Geddes returned my visit, and I drove him around among the farmers of Monroe County, he found precisely the same state of facts. All our good farmers were clover men. Among the good wheat-growers in Michigan, you will find the same state of things.

These are the facts. Let us not quarrel over them.

CHAPTER XXIV.

THE CHEAPEST MANURE A FARMER CAN USE.

I do not know who first said, "The cheapest manure a farmer can use is—clover-seed," but the saying has become part of our agricultural literature, and deserves a passing remark.

I have heard good farmers in Western New York say, that if they had a field sown with wheat that they were going to plow the spring after the crop was harvested, they would sow 10 lbs. of clover-seed on the wheat in the spring. They thought that the growth of the clover in the fall, after the wheat was cut, and the growth the next spring, before the land was plowed, would afford manure worth much more than the cost of the clover-seed.

"I do not doubt it," said the Deacon; "but would it not be better to let the crop grow a few months longer, and then plow it under?"

"But that is not the point," I remarked; "we sometimes adopt a rotation when Indian-corn follows a crop of wheat. In such a case, good farmers sometimes plow the land in the fall, and again the next spring, and then plant corn. This is one method. But I have known, as I said before, good farmers to seed down the wheat with clover; and the following spring, say the third week in May, plow under the young clover, and plant immediately on the furrow. If the land is warm, and in good condition, you will frequently get clover, by this time, a foot high, and will have two or three tons of succulent vegetation to turn under; and the farmer who first recommended the practice to me, said that the cut-worms were so fond of this green-clover that they did not molest the young corn-plants. I once tried the plan myself, and found it to work well; but since then, I have kept so many pigs and sheep, that clover has been too useful to plow under. But we will not discuss this point at present.

"What I wanted to say is this: Here we have a field in wheat. Half of it (A) we seed down with 12 lbs. of clover-seed per acre; the other half (B) not. The clover-seed and sowing on A, cost, say, $2 per acre. We plow B in the fall; this will cost us about as much as the clover-seed sown on A. In the spring, A and B are both plowed and planted to corn. Now, which half of the field will be in the cleanest and best condition, and which will produce the best corn, and the best barley, or oats, afterwards?"

"I vote for A," said the Deacon.

"I vote for A," said the Doctor.

"I vote for A," said the Squire.

"I should think," modestly suggested Charley, "that it would depend somewhat on the soil," and Charley is right. On a clean, moderately rich piece of light, sandy soil, I should certainly expect much better corn, and better barley or oats, on A, where the clover was grown, than on B. But if the field was a strong loam, that needed thorough cultivation to get it mellow enough for corn, I am inclined to think that B would come out ahead. At any rate, I am sure that on my own farm, moderately stiff land, if I was going to plant corn after wheat, I should *not* seed it down with clover. I would plow the wheat-stubble immediately after harvest, and harrow and cultivate it to kill the weeds, and then, six weeks or two months later, I would plow it again. I would draw out manure in the winter, pile it up in the field to ferment, and the next spring spread it, and plow it under, and then—

"And then what?" asked the Deacon.—"Why the truth is," said I, "then I would not plant corn at all. I should either sow the field to barley, or drill in mangel-wurzel or Swede-turnips. But if I *did* plant corn, I should expect better corn than if I had sown clover with the wheat; and the land, if the corn was well cultivated, would be remarkably clean, and in fine condition; and the next time the land was seeded down with clover, we could reasonably expect a great crop."

The truth is, that clover-seed is sometimes a very cheap manure, and farmers are in no danger of sowing too much of it. I do not mean sowing too much seed per acre, but they are in no danger of sowing too many acres with clover. On this point, there is no difference of opinion. It is only when we come to explain the action of clover—when we draw deductions from the facts of the the case—that we enter a field bristling all over with controversy.

"You have just finished threshing," said the Deacon, "and for my part, I would rather hear how your wheat turned out, than to listen to any of your chemical talk about nitrogen, phosphoric acid, and potash."

"The wheat," said I, "turned out full as well as I expected. Fourteen acres of it was after wheat, and eight acres of it after oats. Both these fields were seeded down with clover last year, but the clover failed, and there was nothing to be done but to risk them again with wheat. The remainder was after barley. In all, there was not quite 40 acres, and we had 954 bushels of Diehl wheat. This is not bad in the circumstances; but I shall not be content until I can average, taking one year with another, 35 to 40 bushels per acre. If the land had been rich enough, there would unquestionably have been 40 bushels per acre this year. That is to say, the *season* was quite capable of producing this amount; and I think the mechancial condition of the land was also equal to it; all that was needed was sufficient available plant-food in the soil."

"I can see no reason," said the Doctor, "why you may not average 40 bushels of wheat per acre in a good season."

"The field of 14 acres," said I, "where wheat followed wheat, yielded 23 bushels per acre. Last year it yielded 22 bushels per acre; and so we got in the two years 45 bushels per acre."

This field has had no manure of any kind for years. In fact, since the land was cleared, 40 or 50 years ago, I presume that all the manure that has been applied would not, in the aggregate, be equal to more than a good crop of clover-hay. The available plant-food required to produce these two crops of wheat came from the soil itself, and from the rain, dews, and atmosphere. The land is now seeded down with clover, and with the aid of a bushel or two of plaster per acre, next spring, it is not improbable that, if mown twice for hay next year, it will yield in the two crops three tons of hay per acre.

Now, three tons of clover-hay contain about 33 lbs. of phosphoric acid, 90 lbs. of potash, and 150 lbs. of nitrogen.

The last crop of wheat, of 22 bushels per acre, and say 1,500 lbs. of straw, would contain:

	In the grain.	*In the straw.*	*In total crop.*
Phosphoric acid	11½ lbs.	3¾ lbs.	15¼ lbs.
Potash	6¾ "	9¾ "	16½ "
Nitrogen	23 "	9½ "	32½ "

It seems very unkind in the wheat-plants not to give me more than 22 bushels per acre, when the clover-plants coming after will find phosphoric acid enough for 40 bushels of wheat, and potash and nitrogen enough for nearly 100 bushels of wheat per acre. And these are the three important constituents of plant-food.

Why, then, did I get only 22 bushels of wheat per acre? I got 23 bushels on the same land the year previous, and it is not improbable that if I had sown the same land to wheat again this fall, I should get 12 or 15 bushels per acre again next year. But the clover will find plant-food enough for 40 bushels of wheat.

"There is not much doubt," said the Deacon, "that you will get a good crop of clover, if you will keep the sheep off of the land this fall. But I do not see what you mean by the clover-plants finding food enough for 40 bushels of wheat, while in point of fact, if you had sown the field again to wheat this fall, you would not, as you say, probably get more than 12 or 15 bushels of wheat.

"He means this," said the Doctor. "If he had sown the land to wheat this fall, without manure, he would probably not get over 15 bushels of wheat per acre, and yet you both agree that the land will, in all probability, produce next year, if mown twice, three tons of clover-hay per acre, without any manure.

"Now, if we admit that the clover gets no more nitrogen from the rain and dews, and from the atmosphere, than the wheat will get, then it follows that this soil, which will only produce 15 bushels of wheat per acre, does, in point of fact, contain plant-food enough for 40 bushels of wheat, and the usual proportion of straw.

"The two crops take up from the soil as follows:

	Phosphoric acid.	*Potash.*	*Nitrogen.*
15 bushels wheat and straw..........	10¼ lbs.	11¼ lbs.	22 lbs.
3 tons clover-hay..................	33 "	90 "	150 "

"These facts and figures," continued the Doctor, "are worth looking at and thinking about. Why can not the wheat get as much phosphoric acid out of the soil as the clover?"

"Because," said the Deacon, "the roots of the clover go down deeper into the subsoil than the roots of wheat."

"That is a very good reason, so far as it goes," said I, "but does not include all the facts. I have no sort of doubt, that if I had sown this land to wheat, and put on 75 lbs. of nitrogen per acre, I should have got a wheat-crop containing, in grain and straw, 30 lbs. of phosphoric acid. And so the reason I got 15 bushels of wheat per acre, instead of 40 bushels, is not because the roots of wheat do not go deep enough to find sufficient soluble phosphoric acid."

"Possibly," said the Doctor, "the nitrogen you apply may render the phosphoric acid in the soil more soluble."

"That is true," said I; "and this was the answer Liebig gave to Mr. Lawes. Of which more at some future time. But this answer, like the Deacon's, does not cover all the facts of the case; for a supply of soluble phosphoric acid would not, in all probability, give me a large crop of wheat. I will give you some facts presently bearing on this point.

"What we want to find out is, why the clover can get so much more phosphoric acid, potash, and nitrogen, than the wheat, from the same soil?"

MORE ABOUT CLOVER.

The Deacon seemed to think the Doctor was going to give a scientific answer to the question. "If the clover *can* get more nitrogen, phosphoric acid, and potash, from the same soil than wheat," said he, "why not accept the fact, and act accordingly? You scientific gentlemen want to explain everything, and sometimes make confusion worse confounded. We know that a sheep will grow fat in a pasture where a cow would starve."

"True," said the Doctor, "and that is because the cow gathers food with her tongue, and must have the grass long enough for her to get hold of it; while a sheep picks up the grass with her teeth and gums, and, consequently, the sheep can eat the grass down into the very ground."

"Very well," said the Deacon; "and how do you know but that the roots of the clover gather up their food sheep-fashion, while the wheat-roots eat like a cow?"

"That is not a very scientific way of putting it," said the Doctor; "but I am inclined to think the Deacon has the right idea."

"Perhaps, then," said I, "we had better let it go at that until we get more light on the subject. We must conclude that the wheat can not get food enough from the soil to yield a maximum crop, not because there is not food enough in the field, but the roots of the wheat are so constituted that they can not gather it up; while clover-roots, foraging in the same soil, can find all they want."

"Clover," said the Deacon, "is the scavenger of the farm; like a pig, it gathers up what would otherwise be wasted."

"Of course, these illustrations," said the Doctor, "do not give us any clear idea of *how* the clover-plants take up food. We must recollect that the roots of plants take up their food in solution; and it has just occurred to me that, possibly, Mr. Lawes' experiments on the amount of water given off by plants during their growth, may throw some light on the subject we are discussing."

"Mr. Lawes found," continued the Doctor, "that a wheat-plant, from March 19 to June 28, or 101 days, evaporated through its leaves, etc., 45,713 grains of water; while a clover-plant, standing alongside, and in precisely similar condition, evaporated 55,093 grains. The clover was cut June 28, when in full bloom. The wheat-plant was allowed to grow until ripe, Sept. 7. From June 28 to Sept. 7, or 72 days, the wheat-plant evaporated 67,814 grains."

"One moment," said the Deacon; "as I understand, the clover-plant evaporated more water than the wheat-plant, until the 28th of June, but that during the next 71 days, the wheat-plant evaporated more water than it had during the previous 101 days."

"Yes," said I, "and if these facts prove nothing else, they at least show that there is a great difference between wheat and clover. I was at Rothamsted when these experiments were made. During the first nine days of the experiment, the clover-plant evaporated 399.6 grains of water; while the wheat-plant, standing alongside, evaporated only 128.7 grains. In other words, the clover-plant evaporated three times as much water as the wheat-plant. During the next 31 days, the wheat-plant evaporated 1,267.8 grains, and the clover-plant 1,643.0 grains; but during the next 27 days, from April 28 to May 25, the wheat-plant evaporated 162.4 grains of water per day, while the clover-plant only evaporated 109.2 grains per day. During the next 34 days, from May 25 to June 28, the wheat-plant evaporated 1,177.4 grains per day, and the clover-plant 1,473.5 grains per day."

"In June," said the Deacon, "the clover evaporates ten times as much water per day as it did in May. How much water would an acre of clover evaporate?"

"Let Charley figure it out," said the Doctor. "Suppose each plant occupies 10 square inches of land; there are 6,272,640 square inches in an acre, and, consequently, there would be 627,264 clover-plants on an acre. Each plant evaporated 1,473.5 grains per day, and there are 7,000 grains in a pound."

Charley made the calculation, and found that an acre of clover, from May 25 to June 28, evaporated 528,598 lbs. of water, or 15,547 lbs. per day.

A much more accurate way of ascertaining how much water an acre of clover evaporates is afforded us by these experiments. After the plants were cut, they were weighed and analyzed; and it being known exactly how much water each plant had given off during its growth, we have all the facts necessary to tell us just how much a crop of a given weight would evaporate. In brief, it was found that for each pound of dry substance in the wheat-plant, 247.4 lbs. of water had been evaporated; and for each pound in the clover-plant, 269.1 lbs.

An acre of wheat of 15 bushels per acre of grain, and an equal weight of straw, would exhale during the spring and summer 177¾ tons of water, or calculated on 172 days, the duration of the experiment, 2,055 lbs. per day.

An acre of clover that would make two tons of hay, would pass off through its leaves, in 101 days, 430 tons of water, or 8,600 lbs. per day—more than four times as much as the wheat.

These figures show that, from an agricultural point of view, there is a great difference between wheat and clover; and yet I think the figures do not show the whole of the difference. The clover was cut just at the time when the wheat-plant was entering on its period of most rapid growth and exhalation, and, consequently, the figures given above probably exaggerate the amount of water given off by the wheat during the early part of the season. It is, at any rate, quite clear, and this is all I want to show, that an acre of good clover exhales a much larger amount of water from spring to hay-harvest than an acre of wheat.

"And what," said the Deacon, who was evidently getting tired of the figures, "does all this prove?"

The figures prove that clover can drink a much greater quantity of water during March, April, May, and June, than wheat; and, consequently, to get the same amount of food, it is not necessary that the clover should have as much nitrogen, phosphoric acid, potash, etc., in the water as the wheat-plant requires. I do not know that I make myself understood."

"You want to show," said the Deacon, "that the wheat-plant requires richer food than clover."

Yes, I want to show that, though clover requires *more* food per day than wheat, yet the clover can drink such a large amount of water, that it is not necessary to make the "sap of the soil" so rich in nitrogen, phosphoric acid, and potash, for clover, as it is for wheat. I think this tells the whole story.

Clover is, or may be, the grandest renovating and enriching crop commonly grown on our farms. It owes its great value, not to any power it may or may not possess of getting nitrogen from the atmosphere, or phosphoric acid and potash from the subsoil, but principally, if not entirely, to the fact that the roots can drink up such a large amount of water, and live and thrive on very weak food.

HOW TO MAKE A FARM RICH BY GROWING CLOVER.

Not by growing the clover, and selling it. Nothing would exhaust the land so rapidly as such a practice. We must either plow under the clover, let it rot on the surface, or pasture it, or use it for soiling, or make it into hay, feed it out to stock, and return the manure to the land. If clover got its nitrogen from the atmosphere, we might sell the clover, and depend on the roots left in the ground, to enrich the soil for the next crop. But if, as I have endeavored to show, clover gets its nitrogen from a weak solution in the soil, it is clear, that though for a year or two we might raise good crops from the plant-food left in the clover-roots, yet we should soon find that growing a crop of clover, and leaving only the roots in the soil, is no way to permanently enrich land.

I do not say that such a practice will "exhaust" the land. Fortunately, while it is an easy matter to impoverish land, we should have to call in the aid of the most advanced agricultural science, before we could "exhaust" land of its plant-food. The free use of Nitrate of Soda, or Sulphate of Ammonia, might enable us to do something in the way of exhausting our farms, but it would reduce our balance at a bank, or send us to the poor-house, before we had fully robbed the land of its plant-food.

To exhaust land, by growing and selling clover, is an agricultural impossibility, for the simple reason that, long before the soil is exhausted, the clover would produce such a poverty-stricken crop, that we should give up the attempt.

We can make our land poor, by growing clover, and selling it; or, we can make our land rich, by growing clover, and feeding it out on the farm. Or, rather, we can make our land rich, by draining it where needed, cultivating it thoroughly, so as to develope the latent plant-food existing in the soil, and then by growing clover to take up and organize this plant-food. This is how to make land rich by growing clover. It is not, in one sense, the clover that makes the land rich; it is the draining and cultivation, that furnishes the food for the clover. The clover takes up this food and concentrates it. The clover does not create the plant-food; it merely saves it. It is the thorough cultivation that enriches the land, not the clover.

"I wish," writes a distinguished New York gentleman, who has a farm of barren sand, "you would tell us whether it is best to let clover ripen and rot on the surface, or plow it under when in blossom? I have heard that it gave more nitrogen to the land to let it ripen and rot on it, but as I am no chemist, I do not know."

If, instead of plowing under the clover—say the last of June, it was left to grow a month longer, it is quite possible that the clover-roots and seed would contain more nitrogen than they did a month earlier. It was formerly thought that there was a loss of nitrogen during the ripening process, but the evidence is not altogether conclusive on the point. Still, if I had a piece of sandy land that I wished to enrich by clover, I do not think I should plow it under in June, on the one hand, or let it grow until maturity, and rot down, on the other. I should rather prefer to mow the crop just as it commenced to blossom, and let the clover lie, spread out on the land, as left by the machine. There would, I think, be no loss of fertilizing elements by evaporation, while the clover-hay would act as a mulch, and the second growth of clover would be encouraged by it. Mow this second crop again, about the first week in August. Then, unless it was desirable to continue the process another year, the land might be plowed up in two or three weeks, turning under the two previous crops of clover that are on the surface, together with the green-clover still growing. I believe this would be better than to let the clover exhaust itself by running to seed.

CHAPTER XXV.

DR. VŒLCKER'S EXPERIMENTS ON CLOVER.

In the Journal of the Royal Agricultural Society of England, for 1868, Dr. Vœlcker, the able chemist of the Society, and formerly Professor of Agricultural Chemistry, at the Royal Agricultural College at Cirencester, England, has given us a paper "On the Causes of the Benefits of Clover, as a preparatory Crop for Wheat." The paper has been repeatedly and extensively quoted in this country, but has not been as critically studied as the importance of the subject demands.

"Never mind all that," said the Deacon, "tell us what Dr. Vœlcker says."

"Here is the paper," said I, "and Charley will read it to us." Charley read as follows:

"Agricultural chemists inform us, that in order to maintain the productive powers of the land unimpaired, we must restore to it the phosphoric acid, potash, nitrogen, and other substances, which enter into the composition of our farm crops; the constant removal of organic and inorganic soil constituents, by the crops usually sold off the farm, leading, as is well known, to more or less rapid deterioration and gradual exhaustion of the land. Even the best wheat soils of this and other countries, become more and more impoverished, and sustain a loss of wheat-yielding power, when corn-crops are grown in too rapid succession without manure. Hence, the universal practice of manuring, and that also of consuming oil-cake, corn, and similar purchased food on land naturally poor, or partially exhausted by previous cropping.

"Whilst, however, it holds good as a general rule, that no soil can be cropped for any length of time, without gradually becoming more and more infertile, if no manure be applied to it, or if the fertilizing elements removed by the crops grown thereon, be not by some means or other restored, it is, nevertheless, a fact, that after a heavy crop of clover carried off as hay, the land, far from being less fertile than before, is peculiarly well adapted, even without the addition of manure, to bear a good crop of wheat in the following year, provided the season be favorable to its growth. This fact, indeed, is so well known, that many farmers justly regard the growth of clover as one of the best preparatory operations which the land can undergo, in order to its producing an abundant crop of wheat in the following year. It has further been noticed, that clover mown twice, leaves the land in a better condition, as regards its wheat-producing capabilities, than when mown once only for hay, and the second crop fed off on the land by sheep; for, notwithstanding that in the latter instance the fertilizing elements in the clover-crop are in part restored in the sheep excrements, yet, contrary to expectation, this partial restoration of the elements of fertility to the land has not the effect of producing more or better wheat in the following year, than is reaped on land from off which the whole clover-crop has been carried, and to which no manure whatever has been applied.

"Again, in the opinion of several good, practical agriculturists, with whom I have conversed on the subject, land whereon clover has been grown for seed in the preceding year, yields a better crop of wheat than it does when the clover is mown twice for hay, or even only once, and afterwards fed off by sheep."

"I do not think," said the Deacon, "that this agrees with our experience here. A good crop of clover-seed is profitable, but it is thought to be rather hard on land."

"Such," said I, "is the opinion of John Johnston. He thinks allowing clover to go to seed, impoverishes the soil."

Charley, continued to read:

"Whatever may be the true explanation of the apparent anomalies connected with the growth and chemical history of the clover-plant, the facts just mentioned, having been noticed, not once or twice only, or by a solitary observer, but repeatedly, and by numbers of intelligent farmers, are certainly entitled to credit; and little wisdom, as it strikes me, is displayed by calling them into question, because they happen to contradict the prevailing theory, according to which a soil is said to become more or less impoverished, in proportion to the large or small amount of organic and mineral soil constituents carried off in the produce."

"That is well said," I remarked, "and very truly; but I will not interrupt the reading."

"In the course of a long residence," continues Dr. Vœlcker, "in a purely agricultural district, I have often been struck with the remarkably healthy appearance and good yield of wheat, on land from which a heavy crop of clover-hay was obtained in the preceding year. I have likewise had frequent opportunities of observing, that, as a rule, wheat grown on part of a field whereon clover has been twice mown for hay, is better than the produce of that on the part of the same field on which the clover has been mown only once for hay, and afterwards fed off by sheep. These observations, extending over a number of years, led me to inquire into the reasons why clover is specially well fitted to prepare land for wheat; and in this paper, I shall endeavor, as the result of my experiments on the subject, to give an intelligible explanation of the fact, that clover is so excellent a preparatory crop for wheat, as it is practically known to be.

"By those taking a superficial view of the subject, it may be suggested that any injury likely to be caused by the removal of a certain amount of fertilizing matter, is altogether insignificant, and more than compensated for, by the benefit which results from the abundant growth of clover-roots, and the physical improvement in the soil, which takes place in their decomposition. Looking, however, more closely into the matter, it will be found that in a good crop of clover-hay, a very considerable amount of both mineral and organic substances is carried off the land, and that, if the total amount of such constituents in a crop had to be regarded exclusively as a measure for determining the relative degrees in which different farm crops exhaust the soil, clover would have to be described as about the most exhausting crop in the entire rotation.

"Clover-hay, on an average, and in round numbers, contains in 100 parts:

Water	17.0
Nitrogenous substances, (flesh-forming matters)*	15.6
Non-nitrogenous compounds	59.9
Mineral matter, (ash)	7.5
	100.0

* Containing nitrogen 2.5

"The mineral portion, or ash, in 100 parts of clover-hay, consists of:

Phosphoric acid	7.5
Sulphuric acid	4.3
Carbonic acid	18.0
Silica	3.0
Lime	30.0
Magnesia	8.5
Potash	20.0
Soda, chloride of sodium, oxide of iron, sand, loss, etc	8.7
	100.0

"Let us suppose the land to have yielded four tons of clover-hay per acre. According to the preceding data, we find that such a crop includes 224 lbs. of nitrogen, equal to 272 lbs. of ammonia, and 672 lbs. of mineral matter or ash constituents.

In 672 lbs. of clover-ash, we find:

Phosphoric acid	51½ lbs.
Sulphuric acid	29 "
Carbonic acid	121 "
Silica	20 "
Lime	201 "
Magnesia	57 "
Potash	134½ "
Soda, chloride of sodium, oxide of iron, sand, etc	58 "
	672 lbs.

"Four tons of clover-hay, the produce of one acre, thus contain a large amount of nitrogen, and remove from the soil an enormous quantity of mineral matters, abounding in lime and potash, and containing also a good deal of phosphoric acid.

"Leaving for a moment the question untouched, whether the nitrogen contained in the clover, is derived from the soil, or from the atmosphere, or partly from the one, and partly from the other, no question can arise as to the original source from which the mineral matters in the clover produce are derived. In relation, therefore, to the ash-constituents, clover must be regarded as one of the most exhausting crops usually cultivated in this country. This appears strikingly to be the case, when we compare the preceding figures with the quantity of mineral matters which an average crop of wheat removes from an acre of land.

"The grain and straw of wheat contain, in round numbers, in 100 parts:

	Grains of Wheat.	*Straw.*
Water	15.0	16.0
Nitrogenous substances, flesh-forming matter)*	11.1	4.0
Non-nitrogenous substances	72.2	74.9
Mineral matter, (ash)	1.7	5.1
	100.0	100.0
* Containing nitrogen	1.78	.64

"The ash of wheat contains, in 100 parts:

	Grain.	*Straw.*
Phosphoric acid	50.0	5.0
Sulphuric acid	0.5	2.7
Carbonic acid		
Silica	2.5	67.0
Lime	3.5	5.5
Magnesia	11.5	2.0
Potash	30.0	13.0
Soda, chloride of sodium, oxide of iron, sand, etc.	2.0	4.8
Total	100.0	100.0

"The mean produce of wheat, per acre, may be estimated at 25 bushels, which, at 60 lbs. per bushel, gives 1,500 lbs.; and as the weight of the straw is generally twice that of the grain, its produce will be 3,000 lbs. According, therefore, to the preceding data, there will be carried away from the soil:

In 1,500 lbs. of the grain.. 25 lbs. of mineral food, (in round numbers).
In 3,000 lbs. of the straw.. 150 lbs. of mineral food, (in round numbers).
Total................ 175 lbs.

"On the average of the analyses, it will be found that the composition of these 175 lbs. is as follows:

	In the grain.	*In the straw.*	*Total.*
Phosphoric acid	12.5 lbs.	7.5 lbs.	20.0 lbs.
Sulphuric acid	0.1 "	4.0 "	4.1 "
Carbonic acid			
Silica	0.6 "	100.5 "	101.1 "
Lime	0.9 "	8.2 "	9.1 "
Magnesia	2.9 "	3.0 "	5.9 "
Potash	7.5 "	19.5 "	27.0 "
Soda, chloride of sodium, oxide of iron, sand, etc.	0.5 "	7.3 "	7.8 "
	25. lbs.	150. lbs.	175. lbs.

"The total quantity of ash constituents carried off the land, in an average crop of wheat, thus amounts to only 175 lbs. per acre, whilst a good crop of clover removes as much as 672 lbs.

"Nearly two-thirds of the total amount of mineral in the grain and straw of one acre of wheat, consists of silica, of which there is an ample supply in almost every soil. The restoration of silica, therefore, need not trouble us in any way, especially as there is not a single instance on record, proving that silica, even in a soluble condition, has ever been applied to land, with the slightest advantage to corn, or grass-crops, which are rich in silica, and which, for this reason, may be assumed to be particularly grateful for it in a soluble state. Silica, indeed, if at all capable of producing a beneficial effect, ought to be useful to these crops, either by strengthening the straw, or stems of graminaceous plants, or otherwise benefiting them; but, after deducting the amount of silica from the total amount of mineral matters in the wheat produced from one acre, only a trifling quantity of other and more valuable fertilizing ash constituents of plants will be left. On comparing the relative amounts of phosphoric acid, and potash, in an average crop of wheat, and a good crop of clover-hay, it will be seen that one acre of clover-hay contains as much phosphoric acid, as two and one-half acres of wheat, and as much potash as the produce from five acres of the same crop. Clover thus unquestionably removes from the land very much more mineral matter than does wheat; wheat, notwithstanding, succeeds remarkably well after clover.

"Four tons of clover-hay, or the produce of an acre, contains, as already stated, 224 lbs. of nitrogen, or calculated as ammonia, 272 lbs.

"Assuming the grain of wheat to furnish 1.78 per cent of nitrogen, and wheat-straw, .64 per cent, and assuming also that 1,500 lbs. of corn, and 3,000 lbs. of straw, represent the average produce per acre, there will be in the grain of wheat, per acre, 26.7 lbs. of nitrogen, and in the straw, 19.2 lbs., or in both together, 46 lbs. of nitrogen; in round numbers, equal to about 55 lbs. of ammonia, which is only about one-fifth the quantity of nitrogen in the produce of an acre of clover. Wheat, it is well known, is specially benefited by the application of nitrogenous manures, and as clover carries off so large a quantity of nitrogen, it is natural to expect the yield of wheat, after clover, to fall short of what the land might be presumed to produce without manure, before a crop of clover was taken from it. Experience, however, has proved the fallacy of this presumption, for the result is exactly the opposite, inasmuch as a better and heavier crop of wheat is produced than without the intercalation of clover. What, it may be asked, is the explanation of this apparent anomaly?

"In taking up this inquiry, I was led to pass in review the celebrated and highly important experiments, undertaken by Mr. Lawes and Dr. Gilbert, on the continued growth of wheat on the same soil, for a long succession of years, and to examine, likewise carefully, many points, to which attention is drawn, by the same authors in their memoirs on the growth of red clover by different manures, and on the Lois Weedon plan of growing wheat. Abundant and most convincing evidence is supplied by these indefatigable experimenters, that the wheat-producing powers of a soil are not increased in any sensible degree by the liberal supply of all the mineral matters, which enter into the composition of the ash of wheat, and that the abstraction of these mineral matters from the soil, in any much larger proportions than can possibly take place under ordinary cultivation, in no wise affects the yield of wheat, provided there be at the same time a liberal supply of available nitrogen within the soil itself. The amount of the latter, therefore, is regarded by Messrs. Lawes and Gilbert, as the measure of the increased produce of grain which a soil furnishes.

"In conformity with these views, the farmer, when he wishes to increase the yield of his wheat, finds it to his advantage to have recourse to ammoniacal, or other nitrogenous manures, and depends more or less entirely upon the soil, for the supply of the neccessary mineral or ash-constituents of wheat, having found such a supply to be amply sufficient for his requirements. As far, therefore, as the removal from the soil of a large amount of mineral soil-constituents, by the clover-crop, is concerned, the fact viewed in the light of the Rothamsted experiments, becomes at once intelligible; for, notwithstanding the abstraction of over 600 lbs. of mineral matter by a crop of clover, the succeeding wheat-crop does not suffer. Inasmuch, however, as we have seen, that not only much mineral matter is carried off the land in a crop of clover, but also much nitrogen, we might, in the absence of direct evidence to the contrary, be led to suspect that wheat, after clover, would not be a good crop; whereas, the fact is exactly the reverse.

"It is worthy of notice, that nitrogenous manures, which have such a marked and beneficial effect upon wheat, do no good, but in certain combinations, in some seasons, do positive harm to clover. Thus, Messrs. Lawes and Gilbert, in a series of experiments on the growth of red-clover, by different manures, obtained 14 tons of fresh green produce, equal to about three and three-fourths tons of clover-hay, from the unmanured portion of the experimental field; and where sulphates of potash, soda, and magnesia, or sulphate of potash and superphosphate of lime were employed, 17 to 18 tons, (equal to from about four and one-half to nearly five tons of hay), were obtained. When salts of ammonia were added to the mineral manures, the produce of clover-hay was, upon the whole, less than where the mineral manures were used alone. The wheat, grown after the clover, on the unmanured plot, gave, however, 29½ bushels of corn, whilst in the adjoining field, where wheat was grown after wheat, without manure, only 15½ bushels of corn per acre were obtained. Messrs. Lawes and Gilbert notice especially, that in the clover-crop of the preceding year, very much larger quantities, both of mineral matters and of nitrogen, were taken from the land, than were removed in the unmanured wheat-crop in the same year, in the adjoining field. Notwithstanding this, the soil from which the clover had been taken, was in a condition to yield 14 bushels more wheat, per acre, than that upon which wheat had been previously grown; the yield of wheat, after clover, in these experiments, being fully equal to that in another field, where large quantities of manure were used.

"Taking all these circumstances into account, is there not presumptive evidence, that, notwithstanding the removal of a large amount of nitrogen in the clover-hay, an abundant store of available nitrogen is left in the soil, and also that in its relations towards nitrogen in the soil, clover differs essentially from wheat? The results of our experience in the growth of the two crops, appear to indicate that, whereas the growth of the wheat rapidly exhausts the land of its available nitrogen, that of clover, on the contrary, tends somehow or other to accumulate nitrogen within the soil itself. If this can be shown to be the case, an intelligible explanation of the fact that clover is so useful as a preparatory crop for wheat, will be found in the circumstance, that, during the growth of clover, nitrogenous food, for which wheat is particularly grateful, is either stored up or rendered available in the soil.

"An explanation, however plausible, can hardly be accepted as correct, if based mainly on data, which, although highly probable, are not proved to be based on fact. In chemical inquiries, especially, nothing must be taken for granted, that has not been proved by direct experiment. The following questions naturally suggest themselves in reference to this subject: What is the amount of nitrogen in soils of different characters? What is the amount more particularly after a good, and after an indifferent crop of clover? Why is the amount of nitrogen in soils, larger after clover, than after wheat and other crops? Is the nitrogen present in a condition in which it is available and useful to wheat? And lastly, are there any other circumstances, apart from the supply of nitrogenous matter in the soil, which help to account for the beneficial effects of clover as a preparatory crop for wheat?

"In order to throw some light on these questions, and, if possible, to give distinct answers to at least some of them, I, years ago, when residing at Cirencester, began a series of experiments; and more recently, I have been fortunate enough to obtain the co-operation of Mr. Robert Valentine, of Leighton Buzzard, who kindly undertook to supply me with materials for my analysis.

"My first experiments were made on a thin, calcareous, clay soil, resting on oolitic limestone, and producing generally a fair crop of red-clover. The clover-field formed the slope of a rather steep hillock, and varied much in depth. At the top of the hill, the soil became very stony at a depth of four inches, so that it could only with difficulty be excavated to a depth of six inches, when the bare limestone-rock made its appearance. At the bottom of the field the soil was much deeper, and the clover stronger, than at the upper part. On the brow of the hill, where the clover appeared to be strong, a square yard was measured out; and at a little distance off, where the clover was very bad, a second square yard was measured; in both plots, the soil being taken up to a depth of six inches. The soil, where the clover was good, may be distinguished from the other, by being marked as No. 1, and that where it was bad, as No. 2.

CLOVER-SOIL NO. 1. (GOOD CLOVER).

"The roots having first been shaken out to free them as much as possible from the soil, were then washed once or twice with cold distilled water, and, after having been dried for a little while in the sun, were weighed, when the square yard produced 1 lb. 10½ oz. of cleaned clover-roots, in an air-dry state; an acre of land, or 4,840 square yards, accordingly yielded, in a depth of six inches, 3.44 tons, or 3½ tons in round numbers, of clover-roots.

"Fully dried in a water-bath, the roots were found to contain altogether 44.67 per cent of water, and on being burnt in a platinum capsule, yielded 6.089 of ash. A portion of the dried, finely powdered and well mixed roots, was burned with soda lime, in a combustion tube, and the nitrogen contained in the roots otherwise determined in the usual way. Accordingly, the following is the general composition of the roots from the soil No. 1:

Water	44.675
Organic matter*	49.236
Mineral matter	6.089
	100.000

* Containing nitrogen	1.297
Equal to ammonia	1.575

"Assuming the whole field to have produced 3½ tons of clover-roots, per acre, there will be 99.636 lbs., or in round numbers, 100 lbs. of nitrogen in the clover-roots from one acre; or, about twice as much nitrogen as is present in the average produce of an acre of wheat."

"That is a remarkable fact," said the Deacon, "as I understand nitrogen is the great thing needed by wheat, and yet the *roots* alone of the clover, contain twice as much nitrogen as an average crop of wheat. Go on Charley, it is quite interesting."

"The soil," continues Dr. Vœlcker, "which had been separated from the roots, was passed through a sieve to deprive it of any stones it might contain. It was then partially dried, and the nitrogen in it determined in the usual manner, by combustion with soda-lime, when it yielded .313 per cent of nitrogen, equal to .38 of ammonia, in one combustion; and .373 per cent of nitrogen, equal to .46 of ammonia, in a second determination.

"That the reader may have some idea of the character of this soil, it may be stated, that it was further submitted to a general analysis, according to which, it was found to have the following composition:

GENERAL COMPOSITION OF SOIL, NO. 1. (GOOD CLOVER).

Moisture	18.73
Organic matter*	9.72
Oxide of iron and alumina	13.24
Carbonate of lime	8.82
Magnesia, alkalies, etc	1.72
Insoluble silicious matter, (chiefly clay)	47.77
	100.00

* Containing nitrogen	.313
Equal to ammonia	.380

"The second square yard from the brow of the hill, where the clover was bad, produced 13 ounces of air-dry, and partially clean roots, or 1.75 tons per acre. On analysis, they were found to have the following composition:

CLOVER-ROOTS, NO. 2. (BAD CLOVER).

Water	55.732
Organic matter*	39.408
Mineral matter, (ash)	4.860
	100.000

* Containing nitrogen	.792
Equal to ammonia	.901

"The roots on the spot where the clover was very bad, yielded only 31 lbs. of nitrogen per acre, or scarcely one-third of the quantity which was obtained from the roots where the clover was good.

"The soil from the second square yard, on analysis, was found, when freed from stones by sifting, to contain in 100 parts:

COMPOSITION OF SOIL, NO. 2. (BAD CLOVER).

Water	17.24
Organic matter*	9.64
Oxide of iron and alumina	11.89
Carbonate of lime	14.50
Magnesia, alkalies, etc	1.53
Insoluble silicious matter	45.20
	100.00

		2d determination.
* Containing nitrogen	.306	.380
Equal to ammonia	.370	.470

"Both portions of the clover-soil thus contained about the same percentage of organic matter, and yielded nearly the same amount of nitrogen.

"In addition, however, to the nitrogen in the clover-roots, a good deal of nitrogen, in the shape of root-fibres, decayed leaves, and similar organic matters, was disseminated throughout the fine soil in which it occurred, and from which it could not be separated; but unfortunately, I neglected to weigh the soil from a square yard, and am, therefore, unable to state how much nitrogen per acre was present in the shape of small root-fibres and other organic matters.

"Before mentioning the details of the experiments made in the next season, I will here give the composition of the ash of the partially cleaned clover-roots:

COMPOSITION OF ASH OF CLOVER-ROOTS, (PARTIALLY CLEANED).

Oxide of iron and alumina	11.73
Lime	18.49
Magnesia	3.03
Potash	6.88
Soda	1.93
Phosphoric acid	3.61
Sulphuric acid	2.24
Soluble silica	19.01
Insoluble silicious matter	24.83
Carbonic acid, chlorine, and loss	8.25
	100.00

"This ash was obtained from clover-roots, which yielded, when perfectly dry, in round numbers, eight per cent of ash. Clover-roots, washed quite clean, and separated from all soil, yield about five per cent of ash; but it is extremely difficult to clean a large quantity of fibrous roots from all dirt, and the preceding analysis distinctly shows, that the ash of the clover-roots, analyzed by me, was mechanically mixed with a good deal of fine soil, for oxide of iron, and alumina, and insoluble silicious matter in any quantity, are not normal constituents of plant-ashes. Making allowance for soil contamination, the ash of clover-roots, it will be noticed, contains much lime and potash, as well as an appreciable amount of phosphoric and sulphuric acid. On the decay of the clover-roots, these and other mineral fertilizing matters are left in the surface-soil in a readily available condition, and in considerable proportions, when the clover stands well. Although a crop of clover removes much mineral matter from the soil, it must be borne in mind, that its roots extract from the land, soluble mineral fertiliz-

7

ing matters, which, on the decay of the roots, remain in the land in a prepared and more readily available form, than that in which they originally occur. The benefits arising to wheat, from the growth of clover, may thus be due partly to this preparation and concentration of mineral food in the surface-soil.

"The clover on the hillside field, on the whole, turned out a very good crop; and, as the plant stood the winter well, and this field was left another season in clover, without being plowed up, I availed myself of the opportunity of making, during the following season, a number of experiments similar to those of the preceding year. This time, however, I selected for examination, a square yard of soil, from a spot on the brow of the hill, where the clover was thin, and the soil itself stony at a depth of four inches; and another plot of one square yard at the bottom of the hill, from a place where the clover was stronger than that on the brow of the hill, and the soil at a depth of six inches contained no large stones.

SOIL NO. 1. (CLOVER THIN), ON THE BROW OF THE HILL.

"The roots in a square yard, six inches deep, when picked out by hand, and cleaned as much as possible, weighed, in their natural state, 2 lbs. 11 oz.; and when dried on the top of a water-bath, for the purpose of getting them brittle and fit for reduction into fine powder, 1 lb. 12 oz. 31 grains. In this state they were submitted as before to analysis, when they yielded in 100 parts:

COMPOSITION OF CLOVER-ROOTS, NO. 1, (FROM BROW OF HILL).

Moisture	4.34
Organic matter*	26.53
Mineral matter	69.13
	100.00
* Containing nitrogen	.816
Equal to ammonia	.991

"According to these data, an acre of land will yield three tons 12 cwts. of nearly dry clover-roots, and in this quantity there will be about 66 lbs. of nitrogen. The whole of the soil from which the roots have been picked out, was passed through a half-inch sieve. The stones left in the sieve weighed 141 lbs.; the soil which passed through weighing 218 lbs.

"The soil was next dried by artificial heat, when the 218 lbs. became reduced to 185.487 lbs.

"In this partially dried state it contained:

Moisture	4.21
Organic matter*	9.78
Mineral matter†	86.01
	100.00

* Containing nitrogen	.391
Equal to ammonia	.475
† Including phosphoric acid	.264

"I also determined the phosphoric acid in the ash of the clover-roots. Calculated for the roots in a nearly dry state, the phosphoric acid amounts to .287 per cent.

"An acre of soil, according to the data, furnished by the six inches on the spot where the clover was thin, produced the following quantity of nitrogen:

	Ton.	*Cwts.*	*Lbs.*
In the fine soil	1	11	33
In the clover-roots	0	0	66
Total quantity of nitrogen per acre	1	11	99

"The organic matter in an acre of this soil, which can not be picked out by hand, it will be seen, contains an enormous quantity of nitrogen; and although, probably, the greater part of the roots and other remains from the clover-crop may not be decomposed so thoroughly as to yield nitrogenous food to the succeeding wheat-crop, it can scarcely be doubted that a considerable quantity of nitrogen will become available by the time the wheat is sown, and that one of the chief reasons why clover benefits the succeeding wheat-crop, is to be found in the abundant supply of available nitrogenous food furnished by the decaying clover-roots and leaves.

CLOVER-SOIL NO. 2, FROM THE BOTTOM OF THE HILL. (GOOD CLOVER.)

"A square yard of the soil from the bottom of the hill, where the clover was stronger than on the brow of the hill, produced 2 lbs. 8 oz. of fresh clover-roots; or 1 lb. 11 oz. 47 grains of partially dried roots; 61 lbs. 9 oz. of limestones, and 239.96 lbs. of nearly dry soil.

"The partially dried roots contained:

Moisture	5.06
Organic matter*	31.94
Mineral matter	63.00
	100.00

* Containing nitrogen	.804

"An acre of this soil, six inches deep, produced 3 tons, 7 cwts. 65 lbs. of clover-roots, containing 61 lbs. of nitrogen; that is, there was very nearly the same quantity of roots and nitrogen in them, as that furnished in the soil from the brow of the hill.

"The roots, moreover, yielded .365 per cent of phosphoric acid; or, calculated per acre, 27 lbs.

"In the partially dried soil, I found:

Moisture	4.70
Organic matter*	10.87
Mineral matter†	84.43
	100.00

*Containing nitrogen	.405
Equal to ammonia	.491
†Including phosphoric acid	.321

"According to these determinations, an acre of soil from the bottom of the hill, contains:

	Tons.	*Cwts.*	*Lbs.*
Nitrogen in the organic matter of the soil	2	2	0
Nitrogen in clover-roots of the soil	0	0	61
Total amount of nitrogen per acre	2	2	61

"Compared with the amount of nitrogen in the soil from the brow of the hill, about 11 cwt. more nitrogen was obtained in the soil and roots from the bottom of the hill, where the clover was more luxuriant.

"The increased amount of nitrogen occurred in fine root-fibres and other organic matters of the soil, and not in the coarser bits of roots which were picked out by the hand. It may be assumed that the finer particles of organic matter are more readily decomposed than the coarser roots; and as there was a larger amount of nitrogen in this than in the preceding soil, it may be expected that the land at the bottom of the hill, after removal of the clover, was in a better agricultural condition for wheat, than that on the brow of the hill.

CHAPTER XXVI.

EXPERIMENTS ON CLOVER-SOILS FROM BURCOTT LODGE FARM, LEIGHTON BUZZARD.

"The soils for the next experiments, were kindly supplied to me, in 1866, by Robert Valentine, of Burcott Lodge, who also sent me some notes respecting the growth and yield of clover-hay and seed on this soil.

"Foreign seed, at the rate of 12 lbs. per acre, was sown with a crop of wheat, which yielded five quarters per acre the previous year.

"The first crop of clover was cut down on the 25th of June, 1866, and carried on June 30th. The weather was very warm, from the time of cutting until the clover was carted, the thermometer standing at 80° Fahr. every day. The clover was turned in the swath, on the second day after it was cut; on the fourth day, it was turned over and put into small heaps of about 10 lbs. each; and on the fifth day, these were collected into larger cocks, and then stacked.

"The best part of an 11-acre field, produced nearly three tons of clover-hay, sun-dried, per acre; the whole field yielding on an average, 2½ tons per acre. This result was obtained by weighing the stack three months after the clover was carted. The second crop was cut on the 21st of August, and carried on the 27th, the weight being nearly 30 cwt. of hay per acre. Thus the two cuttings produced just about four tons of clover-hay per acre.

"The 11 acres were divided into two parts. About one-half was mown for hay a second time, and the other part left for seed. The produce of the second half of the 11-acre field, was cut on the 8th of October, and carried on the 10th. It yielded in round numbers, 3 cwt. of clover-seed per acre, the season being very unfavorable for clover-seed. The second crop of clover, mown for hay, was rather too ripe, and just beginning to show seed.

"A square foot of soil, 18 inches deep, was dug from the second portion of the land which produced the clover-hay and clover-seed.

SOIL FROM PART OF 11-ACRE FIELD TWICE MOWN FOR HAY.

"The upper six inches of soil, one foot square, contained all the main roots of 18 strong plants; the next six inches, only small root fibres, and in the third section, a six-inch slice cut down at a depth of 12 inches from the surface, no distinct fibres could be found. The soil was almost completely saturated with rain when it was dug up on the 13th of September, 1866:

	Lbs.
The upper six inches of soil, one foot square, weighed	60
The second " " "	61
The third " " "	63

"These three portions of one foot of soil, 18 inches deep, were dried nearly completely, and weighed again; when the first six inches weighed 51¼ lbs.; the second six inches, 51 lbs. 5 oz.; and the third section, 54 lbs. 2 oz.

"The first six inches contained 3 lbs. of silicious stones, (flints), which were rejected in preparing a sample for analysis; in the two remaining sections there were no large sized stones. The soils were pounded down, and passed through a wire sieve.

"The three layers of soil, dried and reduced to powder, were mixed together, and a prepared average sample, when submitted to analysis, yielded the following results:

COMPOSITION OF CLOVER-SOIL, 18 INCHES DEEP, FROM PART OF 11-ACRE FIELD, TWICE MOWN FOR HAY.

Soluble in hydrochloric acid.	Organic matter	5.86
	Oxides of iron	6.83
	Alumina	7.12
	Carbonate of lime	2.13
	Magnesia	2.01
	Potash	.67
	Soda	.08
	Chloride of sodium	.02
	Phosphoric acid	.18
	Sulphuric acid	.17
Insoluble in acid	Insoluble silicious matter, 74.61. Consisting of:	
	Alumina	4.37
	Lime, (in a state of silicate)	4.07
	Magnesia	.46
	Potash	.19
	Soda	.23
	Silica	65.29
		99.68

"This soil, it will be seen, contained, in appreciable quantities, not only potash and phosphoric acid, but all the elements of fertility which enter into the composition of good arable land. It may be briefly described as a stiff clay soil, containing a sufficiency of lime, potash, and phosphoric acid, to meet all the requirements of the clover-crop. Originally, rather unproductive, it has been much improved by deep culture; by being smashed up into rough clods, early in autumn, and by being exposed in this state to the crumbling effects of the air, it now yields good corn and forage crops.

"In separate portions of the three layers of soil, the proportions of nitrogen and phosphoric acid contained in each layer of six inches, were determined and found to be as follows:

	Soil dried at 212 *deg. Fahr.*		
	1st six inches.	*2d six inches.*	*3d six inches.*
Percentage of phosphoric acid	.249	.134	.172
Nitrogen	1.62	.092	.064
Equal to ammonia	.198	.112	.078

"In the upper six inches, as will be seen, the percentage of both phosphoric acid and nitrogen, was larger than in the two following layers, while the proportion of nitrogen in the six inches of surface soil, was much larger than in the next six inches; and in the third section, containing no visible particles of root-fibres, only very little nitrogen occurred.

"In their natural state, the three layers of soil contained:

	1st six inches.	*2d six inches.*	*3d six inches.*
Moisture	17.16	18.24	16.62
Phosphoric acid	.198	.109	.143
Nitrogen	.134	.075	.053
Equal to ammonia	.162	.091	.064
	lbs.	*lbs.*	*lbs.*
Weight of one foot square of soil	60	61	63

"Calculated per acre, the absolute weight of one acre of this land, six inches deep, weighs:

	Lbs.
1st six inches	2,613,600
2d six inches	2,657,160
3d six inches	2,746,280

"No great error, therefore, will be made, if we assume in the subsequent calculations, that six inches of this soil weighs two and one-half millions of pounds per acre.

"An acre of land, according to the preceding determinations, contains:

	1st six inches, *Lbs.*	*2d six inches,* *Lbs.*	*3d six inches,* *Lbs.*
Phosphoric acid	4,950	2,725	3,575
Nitrogen	3,350	1,875	1,325
Equal to ammonia	4,050	2,275	1,600

"The proportion of phosphoric acid in six inches of surface soil, it will be seen, amounted to about two-tenths per cent; a proportion of the whole soil, so small that it may appear insufficient for the production of a good corn-crop. However, when calculated to the acre, we find that six inches of surface soil in an acre of land, actually contain over two tons of phosphoric acid. An average crop of wheat, assumed to be 25 bushels of grain, at 60 lbs. per bushel, and 3,000 lbs. of straw, removes from the land on which it is grown, 20 lbs. of phosphoric acid. The clover-soil analyzed by me, consequently contains an amount of phosphoric acid in a depth of only six inches, which is equal to that present in 247½ average crops of wheat; or supposing that, by good cultivation and in favorable seasons, the average yield of wheat could be doubled, and 50 bushels of grain, at 60 lbs. a bushel, and 6,000 lbs. of straw could be raised, 124 of such heavy wheat-crops would contain no more phosphoric acid than actually occurred in six inches of this clover-soil per acre.

"The mere presence of such an amount of phosphoric acid in a soil, however, by no means proves its sufficiency for the production of so many crops of wheat; for, in the first place, it can not be shown that the whole of the phosphoric acid found by analysis, occurs in the soil in a readily available combination; and, in the second place, it is quite certain that the root-fibres of the wheat-plant can not reach and pick up, so to speak, every particle of phosphoric acid, even supposing it to occur in the soil in a form most conducive to 'ready assimilation by the plant.'

"The calculation is not given in proof of a conclusion which would be manifestly absurd, but simply as an illustration of the enormous quantity in an acre of soil six inches deep, of a constituent forming the smaller proportions of the whole weight of an acre of soil of that limited depth. It shows the existence of a practically unlimited amount of the most important mineral constituents of plants, and clearly points out the propriety of rendering available to plants, the natural resources of the soil in plant-food; to draw, in fact, up the mineral wealth of the soil, by thoroughly working the land, and not leaving it unutilized as so much dead capital."

"Good," said the Deacon, "that is the right doctrine."

"The roots," continues Dr. Vœlcker, "from one square foot of soil were cleaned as much as possible, dried completely at 212°, and in that state weighed 240 grains. An acre consequently contained 1,493½ lbs. of dried clover-roots.

"The clover-roots contained, dried at 212° Fahr.,

Organic matter*	81.33
Mineral matter,† (ash)	18.67
	100.00

* Yielding nitrogen	1.635
Equal to ammonia	1.985
† Including insoluble silicious matter, (clay and sand)	11.67

"Accordingly the clover-roots in an acre of land furnished 24½ lbs. of nitrogen. We have thus:

	Lbs. of nitrogen.
In the six inches of surface soil	3,350
In large clover-roots	24½
In second six inches of soil	1,875
Total amount of nitrogen in one acre of soil 12 inches deep	5,249½
Equal to ammonia	6,374½

Or in round numbers, two tons six cwt. of nitrogen per acre; an enormous quantity, which must have a powerful influence in encouraging the luxuriant development of the succeeding wheat-crop, although only a fraction of the total amount of nitrogen in the clover remains may become sufficiently decomposed in time to be available to the young wheat-plants.

CLOVER-SOIL FROM PART OF 11-ACRE FIELD OF BURCOTT LODGE FARM, LEIGHTON BUZZARD, ONCE MOWN FOR HAY, AND LEFT AFTERWARDS FOR SEED.

"Produce 2½ tons of clover-hay, and 3 cwt. of seed per acre.

"This soil was obtained within a distance of five yards from the part of the field where the soil was dug up after the two cuttings of hay. After the seed there was some difficulty in finding a square foot containing the same number of large clover-roots, as that on the field twice mown; however, at last, in the beginning of November, a square foot containing exactly 18 strong roots, was found and dug up to a depth of 18 inches. The soil dug after the seed was much drier than that dug after the two cuttings of hay:

The upper six inches deep, one foot square, weighed	56 lbs.
The next " " "	58 "
The third " " "	60 "

"After drying by exposure to hot air, the three layers of soil weighed:

The upper six inches, one foot square	49¾ lbs.
The next " "	50½ "
The third " "	51¼ "

"Equal portions of the dried soil from each six-inch section were mixed together and reduced to a fine powder. An average sample thus prepared, on analysis, was found to have the following composition:

COMPOSITION OF CLOVER-SOIL ONCE MOWN FOR HAY, AND AFTERWARDS LEFT FOR SEED. DRIED AT 212° FAHR.

Soluble in hydrochloric acid.	Organic matter	5.34
	Oxides of iron	6.07
	Alumina	4.51
	Carbonate of lime	7.51
	Magnesia	1.27
	Potash	.52
	Soda	.16
	Chloride of sodium	.03
	Phosphoric acid	.15
	Sulphuric acid	.19
Insoluble in acid	Insoluble silicious matter, 73.84. Consisting of:	
	Alumina	4.14
	Lime (in a state of silicate)	2.69
	Magnesia	.68
	Potash	.24
	Soda	.21
	Silica	65.88
		99.59

"The soil, it will be seen, in general character, resembles the preceding sample; it contains a good deal of potash and phosphoric acid, and may be presumed to be well suited to the growth of clover. It contains more carbonate of lime, and is somewhat lighter than the sample from the part of the field twice mown for hay, and may be termed heavy calcareous clay.

"An acre of this land, 18 inches deep, weighed, when very nearly dry:

	Lbs.
Surface, six inches	2,407,900
Next "	2,444,200
Third "	2,480,500

"Or in round numbers, every six inches of soil weighed per acre 2½ millions of pounds, which agrees tolerably well with the actual weight per acre of the preceding soil.

"The amount of phosphoric acid and nitrogen in each six-inch layer was determined separately as before, when the following results were obtained:

IN DRIED SOIL.

	First six inches.	*Second six inches.*	*Third six inches.*
Percentage of phosphoric acid	.159	.166	.140
Nitrogen	.189	.134	.089
Equal to ammonia	.229	.162	.108

"An acre, according to these determinations, contains in the three separate sections:

	First six inches.	*Second six inches.*	*Third six inches.*
	lbs.	*lbs.*	*lbs.*
Phosphoric acid	3,975	4,150	3,500
Nitrogen	4,725	3,350	2,225
Equal to ammonia	5,725	4,050	2,700

"Here, again, as might naturally be expected, the proportion of nitrogen is largest in the surface, where all the decaying leaves dropped during the growth of the clover for seed are found, and wherein root-fibres are more abundant than in the lower strata. The first six inches of soil, it will be seen, contained in round numbers, 2½ tons of nitrogen per acre, that is, considerably more than was found in the same section of the soil where the clover was mown twice for hay; showing plainly, that during the ripening of the clover-seed, the surface is much enriched by the nitrogenous matter in the dropping leaves of the clover-plant.

" *Clover-roots.*—The roots from one square foot of this soil, freed as much as possible from adhering soil, were dried at 212°, and when weighed and reduced to a fine powder, gave, on analysis, the following results:

Oganic matter*	64.76
Mineral matter†	35.24
	100.00

* Containing nitrogen	1.702
Equal to ammonia	2.066
† Including clay and sand (insoluble silicious matter)	26.04

"A square foot of this soil produced 582 grains of dried clover-roots, consequently an acre yielded 3,622 lbs. of roots, or more than twice the weight of roots obtained from the soil of the same field where the clover was twice mown for hay.

"In round numbers, the 3,622 lbs. of clover-roots from the land mown once, and afterwards left for seed, contained 51½ lbs. of nitrogen.

"The roots from the soil after clover-seed, it will be noticed, were not so clean as the preceding sample, nevertheless, they yielded more nitrogen. In 64.76 of organic matter, we have here 1.702 of nitrogen, whereas, in the case of the roots from the part of the field where the clover was twice mown for hay, we have in 81.33 parts, that is, much more organic matter, and 1.635, or rather less of nitrogen. It is evident, therefore, that the organic matter in the soil after clover-seed, occurs in a more advanced stage of decomposition, than found in the clover-roots from the part of the field twice mown. In the manure, in which the decay of such and similar organic remains proceeds, much of the non-nitrogenous, or carbonaceous matters, of which these remains chiefly, though not entirely, consist, is transformed into gaseous carbonic acid, and what remains behind, becomes richer in nitrogen and mineral matters. A parallel case, showing the dissipation of carbonaceous matter, and the increase in the percentage of nitrogen and mineral matter in what is left behind, is presented to us in fresh and rotten dung; in long or fresh dung, the percentage of organic matter, consisting chiefly of very imperfectly decomposed straw, being larger, and that of nitrogen and mineral matter smaller, than in well-rotted dung.

"The roots from the field after clover-seed, it will be borne in mind, were dug up in November, whilst those obtained from the land twice mown, were dug up in September; the former, therefore, may be expected to be in a more advanced state of decay than the latter, and richer in nitrogen.

"In an acre of soil, after clover-seed, we have:

	Lbs.
Nitrogen in first six inches of soil	4,725
Nitrogen in roots	51½
Nitrogen in second six inches of soil	3,350
Total amount of nitrogen, per acre, in twelve inches of soil	8,126½

"Equal to ammonia, 9,867 lbs.: or, in round numbers, 3 tons and 12½ cwts. of nitrogen per acre; equal to 4 tons 8 cwts. of ammonia.

"This is a very much larger amount of nitrogen than occurred in the other soil, and shows plainly that the total amount of nitrogen accumulates especially in the surface-soil, when clover is grown for seed; thus explaining intelligibly, as it appears to me, why wheat, as stated by many practical men, succeeds better on land where clover is grown for seed, than where it is mown for hay.

"All the three layers of the soil, after clover-seed, are richer in nitrogen than the same sections of the soil where the clover was twice mown, as will be seen by the following comparative statement of results:

	I. Clover-Soil twice mown.			II. Clover-Soil once mown and then left for seed.		
	Upper 6 *inches.*	*Second* 6 *inches.*	*Third* 6 *inches.*	*Upper* 6 *inches.*	*Next* 6 *inches.*	*Lowest* 6 *inches.*
Percentage of nitrogen in dried soil	.168	.092	.064	.189	.134	.089
Equal to ammonia	.198	.112	.078	.229	.162	.108

"This difference in the amount of accumulated nitrogen in clover-land, appears still more strikingly on comparing the total amounts of nitrogen per acre in the different sections of the two portions of the 11-acre field.

PERCENTAGE OF NITROGEN PER ACRE.

	First six inches. *Lbs.*	*Second six inches.* *Lbs.*	*Third six inches.* *Lbs.*
I. In soil, clover twice mown*.........	3,350	1,875	1,325
II. In soil, clover once mown and seeded afterwards†........................	4,725	3,350	2,225
Equal to ammonia:			
* I. Clover twice mown...............	4,050	2,275	1,600
†II. Clover seeded....................	5,725	4,050	2,700

	Lbs.
I. Nitrogen in roots of clover twice mown..................	24⅓
II. Nitrogen in clover, once mown, and grown for seed afterwards..	51⅓
I. Weight of dry roots per acre from Soil I	1,493⅓
II. Weight of dry roots per acre from Soil II.................	3,622
Total amount of nitrogen in 1 acre, 12 inches deep of Soil I*.	5,249⅓
Total amount of nitrogen in 1 acre, 12 inches deep of Soil II†.	8,126⅓
Excess of nitrogen in an acre of soil 12 inches deep, calculated as ammonia in part of field, mown once and then seeded....	3,592⅔
*Equal to ammonia.......................................	6,374⅓
†Equal to ammonia.......................................	9,867

"It will be seen that not only was the amount of large clover-roots greater in the part where clover was grown for seed, but that likewise the different layers of soil were in every instance richer in nitrogen after clover-seed, than after clover mown twice for hay.

"Reasons are given in the beginning of this paper which it is hoped will have convinced the reader, that the fertility of land is not so much measured by the amount of ash constituents of plants which it contains, as by the amount of nitrogen, which, together with an excess of such ash constituents, it contains in an available form. It has been shown likewise, that the removal from the soil of a large amount of mineral matter in a good clover-crop, in conformity with many direct field experiments, is not likely in any degree to affect the wheat-crop, and that the yield of wheat on soils under ordinary cultivation, according to the experience of many farmers, and the direct and numerous experiments of Messrs. Lawes and Gilbert, rises or falls, other circumstances being equal, with the supply of available nitrogenous food which is given to the wheat. This being the case, we can not doubt that the benefits arising from the growth of clover to the succeeding wheat, are mainly due to the fact that an immense amount of nitrogenous food accumulates in the soil during the growth of clover.

"This accumulation of nitrogenous plant-food, specially useful to cereal crops, is, as shown in the preceding experiments, much greater when clover is grown for seed, than when it is made into hay. This affords an intelligible explanation of a fact long observed by good practical men, although denied by others who decline to accept their experience as resting upon trustworthy evidence, because, as they say, land cannot become more fertile when a crop is grown upon it for seed, which is carried off, than when that crop is cut down and the produce consumed on the land. The chemical points brought forward in the course of this inquiry, show plainly that mere speculation as to what can take place in a soil, and what not, do not much advance the true theory of certain agricultural practices. It is only by carefully investigating subjects like the one under consideration, that positive proofs are given, showing the correctness of intelligent observers in the fields. Many years ago, I made a great many experiments relative to the chemistry of farm-yard manure, and then showed, amongst other particulars, that manure, spread at once on the land, need not there and then be plowed in, inasmuch as neither a broiling sun, nor a sweeping and drying wind will cause the slightest loss of ammonia; and that, therefore, the old-fashioned farmer who carts his manure on the land as soon as he can, and spreads it at once, but who plows it in at his convenience, acts in perfect accordance with correct chemical principles involved in the management of farm-yard manure. On the present occasion, my main object has been to show, not merely by reasoning on the subject, but by actual experiments, that the larger the amounts of nitrogen, potash, soda, lime, phosphoric acid, etc., which are removed from the land in a clover-crop, the better it is, nevertheless, made thereby for producing in the succeeding year an abundant crop of wheat, other circumstances being favorable to its growth.

"Indeed, no kind of manure can be compared in point of efficacy for wheat, to the manuring which the land gets in a really good crop of clover. The farmer who wishes to derive the full benefit from his clover-lay, should plow it up for wheat as soon as possible in the autumn, and leave it in a rough state as long as is admissible, in order that the air may find free access into the land, and the organic remains left in so much abundance in a good crop of clover be changed into plant-food; more especially, in other words, in order that the crude nitrogenous organic matter in the clover-roots and decaying leaves, may have time to become transformed into ammoniacal compounds, and these, in the course of time, into nitrates, which I am strongly inclined to think is the form in which nitrogen is assimilated, par excellence by cereal crops,and in which, at all events, it is more efficacious than in any other state of combination wherein it may be used as a fertilizer.

"When the clover-lay is plowed up early, the decay of the clover is sufficiently advanced by the time the young wheat-plant stands in need of readily available nitrogenous food, and this being uniformly distributed through the whole of the cultivated soil, is ready to benefit every single plant. This equal and abundant distribution of food, peculiarly valuable to cereals, is a great advantage, and speaks strongly in favor of clover as a preparatory crop for wheat.

"Nitrate of soda, an excellent spring top-dressing for wheat and cereals in general, in some seasons fails to produce as good an effect as in others. In very dry springs, the rainfall is not sufficient to wash it properly into the soil and to distribute it equally, and in very wet seasons it is apt to be washed either into the drains or into a stratum of the soil not accessible to the roots of the young wheat. As, therefore, the character of the approaching season can not usually be predicted, the application of nitrate of soda to wheat is always attended with more or less uncertainty.

"The case is different, when a good crop of clover-hay has been obtained from the land on which wheat is intended to be grown afterwards. An enormous quantity of nitrogenous organic matter, as we have seen, is left in the land after the removal of the clover-crop; and these remains gradually decay and furnish ammonia, which at first and during the colder months of the year, is retained by the well known absorbing properties which all good wheat-soils possess. In spring, when warmer weather sets in, and the wheat begins to make a push, these ammonia compounds in the soil are by degrees oxidized into nitrates; and as this change into food peculiarly favorable to young cereal plants, proceeds slowly but steadily, we have in the soil itself, after clover, a source from which nitrates are continuously produced; so that it does not much affect the final yield of wheat, whether heavy rains remove some or all of the nitrate present in the soil. The clover remains thus afford a more continuous source from which nitrates are produced, and greater certainty for a good crop of wheat than when recourse is had to nitrogenous top-dressings in the spring.

SUMMARY.

"The following are some of the chief points of interest which I have endeavored fully to develope in the preceding pages:

"1. A good crop of clover removes from the soil more potash, phosphoric acid, lime, and other mineral matters, which enter into the composition of the ashes of our cultivated crops, than any other crop usually grown in this country.

"2. There is fully three times as much nitrogen in a crop of clover as in the average produce of the grain and straw of wheat per acre.

"3. Notwithstanding the large amount of nitrogenous matter and of ash-constituents of plants, in the produce of an acre, clover is an excellent preparatory crop for wheat.

"4. During the growth of clover, a large amount of nitrogenous matter accumulates in the soil.

"5. This accumulation, which is greatest in the surface soil, is due to decaying leaves dropped during the growth of clover, and to an abundance of roots, containing, when dry, from one and three-fourths to two per cent of nitrogen.

"6. The clover-roots are stronger and more numerous, and more leaves fall on the ground when clover is grown for seed, than when it is mown for hay; in consequence, more nitrogen is left after clover-seed, than after hay, which accounts for wheat yielding a better crop after clover-seed than after hay.

"7. The development of roots being checked, when the produce, in a green condition, is fed off by sheep, in all probability, leaves still less nitrogenous matter in the soil than when clover is allowed to get riper and is mown for hay; thus, no doubt, accounting for the observation made by practical men, that, notwithstanding the return of the produce in the sheep excrements, wheat is generally stronger, and yields better, after clover mown for hay, than when the clover is fed off green by sheep.

"8. The nitrogenous matters in the clover remains, on their gradual decay, are finally transformed into nitrates, thus affording a continuous source of food on which cereal crops specially delight to grow.

"9. There is strong presumptive evidence that the nitrogen which exists in the air, in shape of ammonia and nitric acid, and descends, in these combinations, with the rain which falls on the ground, satisfies, under ordinary circumstances, the requirements of the clover-crop. This crop causes a large accumulation of nitrogenous matters, which are gradually changed in the soil into nitrates. The atmosphere thus furnishes nitrogenous food to the succeeding wheat indirectly, and, so to say, gratis.

"10. Clover not only provides abundance of nitrogenous food, but delivers this food in a readily available form (as nitrates), more gradually and continuously, and, consequently, with more certainty of a good result, than such food can be applied to the land in the shape of nitrogenous spring top-dressings."

"Thank you Charley," said the Doctor, "*that is the most remarkable paper I ever listened to.* I do not quite know what to think of it. We shall have to examine it carefully."

"The first three propositions in the Summary," said I, "are unquestionably true. Proposition No. 4, is equally true, but we must be careful what meaning we attach to the word 'accumulate.' The idea is, that clover gathers up the nitrogen in the soil. It does not *increase* the absolute amount of nitrogen. It accumulates it—brings it together."

"Proposition No. 5, will not be disputed; and I think we may accept No. 6, also, though we can not be sure that allowing clover to go to seed, had anything to do with the increased quantity of clover-roots."

"Proposition No. 7, may or may not be true. We have no proof, only a 'probability;' and the same may be said in regard to propositions Nos. 8, 9, and 10."

The Deacon seemed uneasy. He did not like these remarks. He had got the impression, while Charley was reading, that much more was proved than Dr. Vœlcker claims in his Summary.

"I thought," said he, "that on the part of the field where the clover was allowed to go to seed, Dr. Vœlcker found a great increase in the amount of nitrogen."

"That seems to be the general impression," said the Doctor, "but in point of fact, we have no proof that the growth of clover, either for hay or for seed, had anything to do with the quantity of nitrogen and phosphoric acid found in the soil. The *facts* given by Dr. Vœlcker, are exceedingly interesting. Let us look at them:"

"A field of 11 acres was sown to winter-wheat, and seeded down in the spring, with 12 lbs. per acre of clover. The wheat yielded 40 bushels per acre. The next year, on the 25th of June, the clover was mown for hay. We are told that 'the *best part* of the field yielded three tons (6,720 lbs.) of clover-hay per acre; the whole field averaging 2½ tons (5,600 lbs.) per acre.'"

"We are not informed how much land there was of the 'best part,' but assuming that it was half the field, the poorer part must have yielded only 4,480 lbs. of hay per acre, or only two-thirds as much as the other. This shows that there was considerable difference in the quality or condition of the land.

"After the field was mown for hay,it was divided into two parts: one part was mown again for hay, August 21st, and yielded about

30 cwt. (3,360 lbs.) of hay per acre; the other half was allowed to grow six or seven weeks longer, and was then (October 8th), cut for seed. The yield was a little over 5½ bushels of seed per acre. Whether the clover allowed to grow for seed, was on the richer or poorer half of the field, we are not informed.

"Dr. Vœlcker then analyzed the soil. That from the part of the field mown twice for hay, contained per acre:

	First six inches.	*Second six inches.*	*Third six inches.*	*Total*, 18. *inches deep.*
Phosphoric acid........	4,950	2,725	3,575	11,250
Nitrogen................	3,350	1,875	1,325	6,550

"The soil *from the part mown once for hay, and then for seed,* contained per acre:

	First six inches.	*Second six inches.*	*Third six inches.*	*Total*, 18 *inches deep.*
Phosphoric acid........	3,975	4,150	3,500	11,625
Nitrogen................	4,725	3,350	2,225	10,300

"Dr. Vœlcker also ascertained the amount and composition of the clover-*roots* growing in the soil on the two parts of the field. On the *part mown twice for hay*, the roots contained per acre 24½ lbs. of nitrogen. On the *part mown once for hay, and then for seed,* the roots contained 51½ lbs. of nitrogen per acre."

"Now," said the Doctor, "these facts are very interesting, *but there is no sort of evidence tending to show that the clover has anything to do with increasing or decreasing the quantity of nitrogen or phosphoric acid found in the soil.*"

"There was more clover-roots per acre, where the clover was allowed to go to seed. But that may be because the soil happened to be richer on this part of the field. There was, in the first six inches of the soil, 3,350 lbs. of nitrogen per acre, on one-half of the field, and 4,725 lbs. on the other half; and it is not at all surprising that on the latter half there should be a greater growth of clover and clover-roots. To suppose that during the six or seven weeks while the clover was maturing its seed, the clover-plants could accumulate 1,375 lbs. of nitrogen, is absurd."

"But Dr. Vœlcker," said the Deacon, "states, and states truly, that 'more leaves fall on the ground when clover is grown for seed, than when it is mown for hay; and, consequently, more nitrogen is left after clover-seed than after hay, which accounts for wheat yielding a better crop after clover-seed than after hay.'"

"This is all true," said the Doctor, "but we can not accept Dr. Vœlcker's analyses as proving it. To account in this way for the 1,375 lbs. of nitrogen, we should have to suppose that the clover-plants, in going to seed, shed *one hundred tons* of dry clover-leaves per acre! The truth of the matter seems to be, that the part of the field on which the clover was allowed to go to seed, was naturally much richer than the other part, and consequently produced a greater growth of clover and clover-roots."

We can not find anything in these experiments tending to show that we can make land rich by growing clover and selling the crop. The analyses of the soil show that in the first eighteen inches of the surface-soil, there was 6,550 lbs. of nitrogen per acre, on one part of the field, and 10,300 lbs. on the other part. The clover did not create this nitrogen, or bring it from the atmosphere. The wheat with which the clover was seeded down, yielded 40 bushels per acre. If the field had been sown to wheat again, it probably would not have yielded over 25 bushels per acre—and that for want of available nitrogen. And yet the clover got nitrogen enough for over four tons of clover-hay; or as much nitrogen as a crop of wheat of 125 bushels per acre, and 7½ tons of straw would remove from the land.

Now what does this prove? There was, in 18 inches of the soil on the poorest part of the field, 6,550 lbs. of nitrogen per acre. A crop of wheat of 50 bushels per acre, and twice that weight of straw, would require about 92 lbs. of nitrogen. But the wheat can not get this amount from the soil, while the clover can get *double the quantity.* And the only explantion I can give, is, that the clover-roots can take up nitrogen from a weaker solution in the soil than wheat-roots can.

"These experiments of Dr. Vœlcker," said I, "give me great encouragement. Here is a soil, 'originally rather unproductive, but much improved by deep culture; by being smashed up into rough clods early in autumn, and by being exposed in this state to the crumbling effects of the air.' It now produces 40 bushels of wheat per acre, and part of the field yielded three tons of clover-hay, per acre, the first cutting, and 5½ bushels of clover-seed afterwards—and that in a very unfavorable season for clover-seed."

You will find that the farmers in England do not expect to make their land rich, by growing clover and selling the produce. After they have got their land rich, by good cultivation, and the liberal use of animal and artificial manures, they may expect a good crop of wheat from the roots of the clover. But they take good care to feed out the clover itself on the farm, in connection with turnips and oil-cake, and thus make rich manure.

And so it is in this country. Much as we hear about the value of clover for manure, even those who extol it the highest do not depend upon it alone for bringing up and maintaining the fertility of their farms. The men who raise the largest crops and make the most money by farming, do not sell clover-hay. They do not look to the roots of the clover for making a poor soil rich. They are, to a man, good cultivators. They work their land thoroughly and kill the weeds. They keep good stock, and feed liberally, and make good manure. They use lime, ashes, and plaster, and are glad to draw manure from the cities and villages, and muck from the swamps, and not a few of them buy artificial manures. In the hands of such farmers, clover is a grand renovating crop. It gathers up the fertility of the soil, and the roots alone of a large crop, often furnish food enough for a good crop of corn, potatoes, or wheat. But if your land was not in good heart to start with, you would not get the large crop of clover; and if you depend on the clover-roots alone, the time is not far distant when your large crops of clover will be things of the past.

AMOUNT OF ROOTS LEFT IN THE SOIL BY DIFFERENT CROPS.

We have seen that Dr. Vœlcker made four separate determinations of the amount of clover-roots left in the soil to the depth of six inches. It may be well to tabulate the figures obtained:

CLOVER-ROOTS, IN SIX INCHES OF SOIL, PER ACRE.

			Air-dry roots, per acre.	*Nitrogen in roots, per acre.*	*Phosphoric acid in roots, per acre.*
No. 1.	1st Year.	Good Clover from brow of the hill......	7705	100	
" 2.	1st Year.	Bad " " " " " "	3920	31	
" 3.	2d Year.	Good Clover from bottom of the field.....	7569	61	27
" 4.	2d Year.	Thin " " brow " hill....	8064	66	
" 5.		Heavy crop of first-year clover mown twice for hay....................................		24½	
" 6.		Heavy crop of first-year clover, mown once for hay, and then for seed.		51½	
" 7.		German experiment, 10¼ inches deep.........	8921	191½	74¾

I have not much confidence in experiments of this kind. It is so easy to make a little mistake; and when you take only a square foot of land, as was the case with Nos. 5 and 6, the mistake is multiplied by 43,560. Still, I give the table for what it is worth.

Nos. 1 and 2 are from a one-year-old crop of clover. The field was a calcareous clay soil. It was somewhat hilly; or, perhaps, what we here, in Western New York, should call "rolling land." The soil on the brow of the hill, "was very stony at a depth of four inches, so that it could only with difficulty be excavated to six inches, when the bare limestone-rock made its appearance."

A square yard was selected on this shallow soil, where the clover was good; and the roots, air-dried, weighed at the rate of 7,705 lbs. per acre, and contained 100 lbs. of nitrogen. A few yards distance, on the same soil, where the clover was bad, the acre of roots contained only 31 lbs. of nitrogen per acre.

So far, so good. We can well understand this result. Chemistry has little to do with it. There was a good stand of clover on the one plot, and a poor one on the other. And the conclusion to be drawn from it is, that it is well worth our while to try to secure a good catch of clover.

"But, suppose," said the Doctor, "No. 2 had happened to have been pastured by sheep, and No. 1 allowed to go to seed, what magic there would have been in the above figures!"

Nos. 3 and 4 are from the same field, the second year. No. 4 is from a square yard of thin clover on the brow of the hill, and No. 3, from the richer, deeper land towards the bottom of the hill.

There is very little difference between them. The roots of thin clover from the brow of the hill, contain five lbs. more nitrogen per acre, than the roots on the deeper soil.

If we can depend on the figures, we may conclude that on our poor stony "knolls," the clover has larger and longer roots than on the richer parts of the field. We know that roots will run long distances and great depths in search of food and water.

Nos. 5 and 6 are from a heavy crop of one-year-old clover. No. 5 was mown twice for hay, producing, in the two cuttings, over four tons of hay per acre. No. 6 was in the same field, the only difference being that the clover, instead of being cut the second time for hay, was allowed to stand a few weeks longer to ripen its seed. You will see that the latter has more roots than the former.

There are 24½ lbs. of nitrogen per acre in the one case, and 51½ lbs. in the other. How far this is due to difference in the condition of the land, or to the difficulties in the way of getting out all the roots from the square yard, is a matter of conjecture.

Truth to tell, I have very little confidence in any of these figures. It will be observed that I have put at the bottom of the table, the result of an examination made in Germany. In this case, the nitrogen in the roots of an acre of clover, amounted to 191½ lbs. per acre. If we can depend on the figures, we must conclude that there were nearly eight times as much clover-roots per acre in the German field, as in the remarkably heavy crop of clover in the English field No. 5.

"Yes," said the Deacon, "but the one was 10¼ inches deep, and the other only six inches deep; and besides, the German experiment includes the 'stubble' with the roots."

The Deacon is right; and it will be well to give the complete table, as published in the *American Agriculturist*:

TABLE SHOWING THE AMOUNT OF ROOTS AND STUBBLE LEFT PER ACRE BY DIFFERENT CROPS, AND THE AMOUNT OF INGREDIENTS WHICH THEY CONTAIN PER ACRE.

	No. of lbs. of stubble & roots (dry) per acre to a depth of 10¼ inches.	*No. of lbs. of Nitrogen per acre.*	*No. of lbs. of ash, free from carbonic acid, per acre.*
Lucern (4 years old)	9,678.1	136.4	1,201.6
Red-Clover (1 year old)	8,921.6	191.6	1,919.9
Esparsette (3 years old)	5,930.9	123.2	1,023.4
Rye	5,264.6	65.3	1,747.8
Swedish Clover	5,004.3	102.3	974.6
Rape	4,477.	56.5	622.3
Oats	3,331.9	26.6	1,444.7
Lupine	3,520.9	62.2	550.
Wheat	3,476.	23.5	1,089.8
Peas	3,222.5	55.6	670.7
Serradella	3,120.1	64.8	545.6
Buckwheat	2,195.6	47.9	465.5
Barley	1,991.4	22.8	391.1

CONTENTS OF THE ASHES, IN POUNDS, PER ACRE.

	Lime.	*Magnesia.*	*Potash.*	*Soda.*	*Sulphuric Acid.*	*Phosphoric Acid.*
Lucern	197.7	24.2	36.7	26.4	18.7	38.5
Red-Clover	262.9	48.4	58.3	20.0	26.1	74.8
Esparsette	132.8	28.7	42.6	13.8	20.6	29.7
Rye	73.2	14.3	31.2	43.3	11.8	24.4
Swedish Clover	136.1	17.6	25.9	5.7	13.2	24.2
Rape	163.9	12.9	34.7	20.9	30.8	31.9
Oats	85.5	11.2	24.8	18.	8.8	29.
Lupine	80.5	11.2	16.5	3.5	7.	13.8
Wheat	76.7	10.1	28.4	11.	7.4	11.8
Peas	71.7	11.	11.2	7.	9.4	14.3
Serradella	79.8	13.4	8.8	4.8	9.	18.4
Buckwheat	80.	7.2	8.8	4.2	6.6	11.
Barley	42.2	5.5	9.5	3.5	5.5	11.2

It may be presumed, that, while these figures are not *absolutely*, they are *relatively*, correct. In other words, we may conclude, that red-clover leaves more nitrogen, phosphoric acid, and potash, in the roots and stubble per acre, than any other of the crops named.

The gross amount of dry substance in the roots, and the gross amount of ash per acre, are considerably exaggerated, owing to the evidently large quantity of dirt attached to the roots and stubble. For instance, the gross amount of ash in Lucern is given as 1,201.6 lbs. per acre; while the total amount of lime, magnesia, potash, soda, sulphuric and phosphoric acids, is only 342.2 lbs. per acre, leaving 859.4 lbs. as sand, clay, iron, etc. Of the 1,919.9 lbs. of ash in the acre of clover-roots and stubble, there are 1,429.4 lbs. of sand, clay, etc. But even after deducting this amount of impurities from a gross total of dry matter per acre, we still have 7,492.2 lbs. of dry roots and stubble per acre, or nearly 3¼ tons of *dry* roots per acre. This is a very large quantity. It is as much dry matter as is contained in 13 tons of ordinary farm-yard, or stable-manure. And these 3¼ tons of dry clover-roots contain 191½ lbs. of nitrogen, which is as much as is contained in 19 tons of ordinary stable-manure. The clover-roots also contain 74¾ lbs. of phosphoric acid per acre, or as much as is contained in from 500 to 600 lbs. of No. 1 rectified Peruvian guano.

"But the phosphoric acid," said the Doctor, "is not soluble in the roots." True, but it was soluble when the roots gathered it up out of the soil.

"These figures," said the Deacon, "have a very pleasant look. Those of us who have nearly one-quarter of our land in clover every year, ought to be making our farms very rich."

"It would seem, at any rate," said I, "that those of us who have good, clean, well-drained, and well-worked land, that is now producing a good growth of clover, may reasonably expect a fair crop of wheat, barley, oats, corn, or potatoes, when we break it up and plow under all the roots, which are equal to 13 or 19 tons of stable-manure per acre. Whether we can or can not depend on these figures, one thing is clearly proven, both by the chemist and the farmer, that a good clover-sod, on well-worked soil, is a good preparation for corn and potatoes."

MANURES FOR WHEAT.

Probably nine-tenths of all the wheat grown in Western New York, or the "Genesee country," from the time the land was first cleared until 1870, was raised without any manure being directly applied to the land for this crop. Tillage and clover were what the farmers depended on. There certainly has been no systematic manuring. The manure made during the winter, was drawn out in the spring, and plowed under for corn. Any manure made during the summer, in the yards, was, by the best farmers, scraped up and spread on portions of the land sown, or to be sown, with wheat. Even so good a farmer and wheat-grower as John Johnston, rarely used manure, (except lime, and latterly, a little guano), directly for wheat. Clover and summer-fallowing were for many years the dependence of the Western New York wheat-growers.

"One of the oldest and most experienced millers of Western New York," remarked the Doctor, "once told me that 'ever since our farmers began to *manure their land*, the wheat-crop had deteriorated, not only in the yield per acre, but in the quality and quantity of the flour obtained from it.' It seemed a strange remark to make; but when he explained that the farmers had given up summer-fallowing and plowing in clover, and now sow spring crops, to be followed by winter wheat with an occasional dressing of poor manure, it is easy to see how it may be true."

"Yes," said I, "it is not the *manure* that hurts the wheat, but the growth of spring crops and weeds that rob the soil of far more plant-food than the poor, strawy manure can supply. We do not now, really, furnish the wheat-crop as much manure or plant-food as we formerly did when little or no manure was used, and when we depended on summer-fallowing and plowing in clover."

We must either give up the practice of sowing a spring crop, before wheat, or we must make more and richer manure, or we must plow in more clover. The rotation, which many of us now adopt —corn, barley, wheat—is profitable, provided we can make our land rich enough to produce 75 bushels of shelled corn, 50 bushels of barley, and 35 bushels of wheat, per acre, in three years.

This can be done, but we shall either require a number of acres of rich low land, or irrigated meadow, the produce of which will make manure for the upland, or we shall have to purchase oil-cake, bran, malt-combs, or refuse beans, to feed out with our straw and clover-hay, or we must purchase artificial manures. Unless this is done, we must summer-fallow more, on the heavier clay soils, sow less oats and barley; or we must, on the lighter soils, raise and plow under more clover, or feed it out on the farm, being careful to save and apply the manure.

"Better do both," said the Doctor."

"How?" asked the Deacon.

"You had better make all the manure you can," continued the Doctor, "and buy artificial manures besides."

"The Doctor is right," said I, "and in point of fact, our best farmers are doing this very thing. They are making more manure and buying more manure than ever before; or, to state the matter correctly, they are buying artificial manures; and these increase the crops, and the extra quantity of straw, corn, and clover, so obtained, enables them to make more manure. They get cheated sometimes in their purchases; but, on the whole, the movement is a good one, and will result in a higher and better system of farming."

I am amused at the interest and enthusiasm manifested by some of our farmers who have used artificial manures for a year or two. They seem to regard me as a sad old fogy, because I am now depending almost entirely on the manures made on the farm. Years ago, I was laughed at because I used guano and superphosphate. It was only yesterday, that a young farmer, who is the local agent of this neighborhood, for a manure manufacturer, remarked to me, "You have never used superphosphate. We sowed it on our wheat last year, and could see to the very drill mark how far it went. I would like to take your order for a ton. I am sure it would pay."

"We are making manure cheaper than you can sell it to me, "I replied, "and besides, I do not think superphosphate is a good manure for wheat." —"Oh," he exclaimed, "you would not say so if you had ever used it."—"Why, my dear sir," said I, "I made tons of superphosphate, and used large quantities of guano before you were born; and if you will come into the house, I will show you a silver goblet I got for a prize essay on the use of superphosphate of lime, that I wrote more than a quarter of a century ago. I sent to New York for two tons of guano, and published the result of its use on this farm, before you were out of your cradle. And I had a ton or more of superphosphate made for me in 1856, and some before that. I have also used on this farm, many tons of superphosphate and other artificial manures from different manufacturers, and one year I used 15 tons of bone-dust."

With ready tact, he turned the tables on me by saying: "Now I can understand why your land is improving. It is because you have used superphosphate and bone-dust. Order a few tons."

By employing agents of this kind, the manufacturers have succeeded in selling the farmers of Western New York thousands of tons of superphosphate. Some farmers think it pays, and some that it does not. We are more likely to hear of the successes than of failures. Still there can be no doubt that superphosphate has, in many instances, proved a valuable and profitable manure for wheat in Western New York.

From 200 to 300 lbs. are used per acre, and the evidence seems to show that it is far better to *drill in the manure with the seed* than to sow it broadcast.

My own opinion is, that these superphosphates are not the most economical artificial manures that could be used for wheat. They contain too little nitrogen. Peruvian guano containing nitrogen equal to 10 per cent of ammonia, would be, I think, a much more effective and profitable manure. But before we discuss this question, it will be necessary to study the results of actual experiments in the use of various fertilizers for wheat.

CHAPTER XXVII.

LAWES AND GILBERT'S EXPERIMENTS ON WHEAT.

I hardly know how to commence an account of the wonderful experiments made at Rothamsted, England, by John Bennett Lawes, Esq., and Dr. Joseph H. Gilbert. Mr. Lawes' first systematic experiment on wheat, commenced in the autumn of 1843. A field of 14 acres of rather heavy clay soil, resting on chalk, was selected for the purpose. Nineteen plots were accurately measured and staked off. The plots ran the long way of the field, and up a slight ascent. On each side of the field, alongside the plots, there was some land not included, the first year, in the experiment proper. This land was either left without manure, or a mixture of the manures used in the experiments was sown on it.

I have heard it said that Mr. Lawes, at this time, was a believer in what was called "Liebig's Mineral Manure Theory." Liebig had said that "The crops on a field, diminish or increase in exact proportion to the diminution or increase of the mineral substances conveyed to it in manure." And enthusiastic gentlemen have been known to tell farmers who were engaged in drawing out farm-yard manure to their land, that they were wasting their strength; all they needed was the mineral elements of the manure. "And you might," they said, "burn your manure, and sow the ashes, and thus save much time and labor. The ashes will do just as much good as the manure itself."

Whether Mr. Lawes did, or did not entertain such an opinion, I do not know. It looks as though the experiments the first year or two, were made with the expectation that mineral manures, or the ashes of plants, were what the wheat needed.

The following table gives the kind and quantities of manures used per acre, and the yield of wheat per acre, as carefully cleaned for market. Also the total weight of grain per acre, and the weight of straw and chaff per acre.

EXPERIMENTS AT ROTHAMSTED ON THE GROWTH OF WHEAT, YEAR AFTER YEAR, ON THE SAME LAND.

TABLE 1.—MANURES AND PRODUCE; 1ST SEASON, 1843–4. MANURES AND SEED (OLD RED LAMMAS) SOWN AUTUMN 1843.

Plots.	MANURES PER ACRE.									PRODUCE PER ACRE, ETC.							INCREASE PER ACRE BY MANURE.			
	Farmyard Manure.	*Farmyard Manure Ashes.*[1]	*Silicate of Potass.*[2]	*Phosphate of Potass.*[3]	*Phosphate of Soda.*[3]	*Phosphate of Magnesia*[3]	*Superphosphate of Lime.*[3]	*Sulphate of Ammonia.*	*Rape Cake*	*Dressed Corn. Quantity*[5]		*Dressed Corn. Weight per Bushel.*	*Offal Corn.*[5]	*Total Corn.*	*Straw and Chaff.*	*Total Produce (Corn and Straw).*	*Corn.*	*Straw and Chaff.*	*Total Produce.*	*Corn to 100 Straw.*
	Tons.	Cwts.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	Bush.	Pks.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	
0	Mixture of the residue of most of the other manures.								..	19	3¾	58.5	61	1228	1436	2664	305	316	621	85.5
1	..	..	..	..	..	..	700	..	154	16	3	59.0	52	1040	1203	2243	117	83	200	86.4
2	14	..	..	..	..	..	..	..	..	20	1¾	59.3	64	1276	1476	2752	353	356	709	86.4
3	Unmanured.		..	..	..	..	..	..	..	15	0	58.5	46	923	1120	2043	..	..	..	82.4
4	..	32[1]	..	..	..	..	..	..	..	14	2¼	58.0	44	888	1104	1992	—35	—16	—51	80.4
5	..	..	..	..	..	..	700	..	..	15	2¼	58.3	48	956	1116	2072	33	— 4	29	85.6
6	..	..	..	..	..	420	350	..	..	15	1	60.0	48	964	1100	2064	41	—20	21	87.6
7	..	..	..	..	325	..	350	..	..	15	2	60.3	49	984	1172	2156	61	52	113	84.0
8	..	..	..	375	..	..	350	..	..	15	0¾	61.3	49	980	1160	2140	57	40	97	84.5
9	..	..	..	..	..	..	630	65	..	19	2¼	62.3	64	1280	1368	2648	357	248	605	93.5
10	..	..	220	..	..	..	560	..	..	15	1¾	62.0	50	1008	1112	2120	85	— 8	77	90.6
11	..	..	..	..	..	..	350	..	308	17	0¾	61.8	56	1116	1200	2316	193	80	273	93.0
12	..	..	..	..	162½	210	350	..	..	15	2	61.5	50	1004	1116	2120	81	— 4	77	90.0
13	..	..	..	187½	..	210	350	..	..	16	1¼	62.5	54	1072	1204	2276	149	84	233	89.0
14	..	..	275	..	..	210	350	..	..	15	3	61.3	51	1016	1176	2192	93	56	149	86.4
15	..	..	110	150	..	168	350	..	..	16	3¼	62.0	55	1096	1240	2336	173	120	293	88.4
16	..	..	110	75	65	84	350	65	..	19	3¼	62.5	65	1304	1480	2784	381	360	741	88.1
17	..	..	110	75	65	84	350[4]	65	..	18	3¾	62.3	62	1240	1422	2662	317	302	619	87.2
18	..	..	110	75	65	84	350	65	154	20	3¾	62.0	68	1368	1768	3136	445	648	1093	77.4
19	..	..	110	..	81	105	350	81	..	24	1¼	61.8	79	1580	1772	3352	657	652	1309	89.2
20	Unmanured.		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
21 } 22 }	Mixture of the residue of most of the other manures.						..	..	..	..	..	..	..	..	..	..	..	..	..	..

[1] The farmyard dung was burnt slowly in a heap in the open air to an imperfect or coaly ash, and 32 cwts. of ash represent 14 tons of dung.

[2] The silicate of potass was manufactured at a glass-house, by fusing equal parts of pearl-ash and sand. The product was a

These were the results of the harvest of 1844. The first year of these since celebrated experiments.

If Mr. Lawes expected that the crops would be in proportion to the minerals supplied in the manure, he must have been greatly disappointed. The plot without manure of any kind, gave 15 bushels of wheat per acre; 700 lbs. of superphosphate of lime, made from burnt bones, produced only 33 lbs. or about half a bushel more grain per acre, and 4 lbs. *less* straw than was obtained without manure. 640 lbs. of superphosphate, and 65 lbs. of commercial sulphate of ammonia (equal to about 14 lbs. of ammonia), gave a little over 19½ bushels of dressed wheat per acre. As compared with the plot having 700 lbs. of superphosphate per acre, this 14 lbs. of available ammonia per acre, or, say 11½ lbs. nitrogen, gave an increase of 324 lbs. of grain, and 252 lbs. of straw, or a total increase of 576 lbs. of grain and straw.

On plot No. 19, 81 lbs. of sulphate ammonia, with minerals, produces 24¼ bushels per acre. This yield is clearly due to the ammonia.

The rape-cake contains about 5 per cent of nitrogen, and is also rich in minerals and *carbonaceous matter*. It gives an increase, but not as large in proportion to the nitrogen furnished, as the sulphate of ammonia. And the same remarks apply to the 14 tons of farm-yard manure.

We should have expected a greater increase from such a liberal dressing of barn-yard manure. I think the explanation is this:

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transparent glass, slightly deliquescent in the air, which was ground to a powder under edge-stones.

[3] The manures termed superphosphate of lime, phosphate of potass, phosphate of soda, and phosphate of magnesia, were made by acting upon bone-ash by means of sulphuric acid in the first instance, and in the cases of the alkali salts and the magnesian one neutralizing the compound thus obtained by means of cheap preparations of the respective bases. For the superphosphate of lime, the proportions were 5 parts bone-ash, 3 parts water, and 3 parts sulphuric acid of sp. gr. 1.84; and for the phosphates of potass, soda, and magnesia, they were 4 parts bone-ash, water as needed, 3 parts sulphuric acid of sp. gr. 1.84, and equivalent amounts, respectively, of pearl-ash, soda-ash, or a mixture of 1 part medicinal carbonate of magnesia, and 4 parts magnesian limestone. The mixtures, of course, all lost weight considerably by the evolution of water and carbonic acid.

[4] Made with unburnt bones.

[5] In this first season, neither the weight nor the measure of the offal corn was recorded separately; and in former papers, the bushels and pecks of total corn (including offal) have erroneously been given as dressed corn. To bring the records more in conformity with those relating to the other years, 5 per cent, by weight, has been deducted from the total corn previously stated as dressed corn, and is recorded as offal corn; this being about the probable proportion, judging from the character of the season, the bulk of the crop, and the weight per bushel of the dressed corn. Although not strictly correct, the statements of dressed corn, as amended in this somewhat arbitrary way, will approximate more nearly to the truth, and be more comparable with those relating to other seasons, than those hitherto recorded.

The manure had not been piled. It was probably taken out fresh from the yard (this, at any rate, was the case when I was at Rothamsted), and plowed under late in the season. And on this heavy land, manure will lie buried in the soil for months, or, if undisturbed, for years, without decomposition. In other words, while this 14 tons of barn-yard manure, contained at least 150 lbs. of nitrogen, and a large quantity of minerals and carbonaceous matter, it did not produce a bushel per acre more than a manure containing less than 12 lbs. of nitrogen. And on plot 19, a manure containing less than 15 lbs. of available nitrogen, produced nearly 4 bushels per acre more wheat than the barn-yard manure containing at least *ten times* as much nitrogen.

There can be but one explanation of this fact. The nitrogen in the manure lay dormant in this heavy soil. Had it been a light sandy soil, it would have decomposed more rapidly and produced a better effect.

As we have before stated, John Johnston finds, on his clay-land, a far greater effect from manure spread on the surface, where it decomposes rapidly, than when the manure is plowed under.

The Deacon was looking at the figures in the table, and not paying much attention to our talk. "What could a man be thinking about," he said, "to burn 14 tons of good manure! It was a great waste, and I am glad the ashes did no sort of good."

After the wheat was harvested in 1844, the land was immediately plowed, harrowed, etc.; and in a few weeks was plowed again and sown to wheat, the different plots being kept separate, as before.

The following table shows the manures used this second year, and the yield per acre:

Experiments at Rothamsted on the Growth of Wheat, Year after Year, on the same Land.

TABLE II.—MANURES AND PRODUCE; 2ND SEASON, 1845. MANURES AND SEED (OLD RED LAMMAS) SOWN MARCH 1845.

Plots.	Manures per Acre.												Produce per Acre, etc.							Incr'se ℔ Acre by Manure.			Offal Corn to 100 Dressed.	Corn to 100 Straw.
	Farmyard Manure.	Silicate of Potass.[1]	Phosph'te of Potass.[2]	S'rphosph'te of Lime.[2]	Bone-ash.	Muriatic Acid.	Guano.	Sulphate of Ammonia.	Muriate of Ammonia.	Carb'nate of Ammonia.	Rape Cake.	Tapioca.	Dressed Corn. Quantity.		Dressed Corn. W'ght ℔ Bushel.	Offal Corn.	Total Corn.	Straw and Chaff.	Total Produce (Corn and Straw).	Corn.	Straw and Chaff.	Total Produce.		
	Tons.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	Bush.	P'cks.	lbs.	lbs	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.		
0	Mixture of the residue of most of the other manures.											..	32	0	56.5	159	1967	3977	5944	526	1265	1791	10.9	49.5
1	..	112	..	..	..	..	..	224	..	..	560	..	26	1¼	54.8	248	1689	3699	5388	248	987	1235	17.2	45.7
2	14	..	..	..	..	..	..	..	..	..	..	..	32	0	56.8	151	1967	3915	5882	526	1203	1729	8.9	50.2
3	Unmanured.		..	..	..	..	..	..	..	..	..	..	23	0¾	56.5	131	1441	2712	4153	..	..	..	8.7	53.1
4	..	..	..	..	112	112	..	112	..	..	..	..	29	2½	58.0	161	1879	3663	5542	438	951	1389	9.4	51.3
5[4] } 1	Unmanured.		..	..	..	..	..	..	..	..	..	..	22	2¼	57.5	134	1431	2684	4115	−10	−28	−38	10.1	53.3
5[4] } 2	..	..	..	..	..	..	..	..	..	252[3]	..	..	26	3¾	57.3	190	1732	3599	5331	291	887	1178	14.2	48.1
6	..	..	..	112	..	..	..	112	..	..	560	..	28	2¾	57.8	214	1871	3644	5515	430	932	1362	14.1	57.3
7	..	..	..	112	..	..	..	112	..	..	..	560	26	2¾	57.0	161	1682	3243	4925	241	531	772	11.3	51.9
8	..	..	..	..	..	..	..	112	..	..	560	..	27	0¼	56.3	194	1716	3063	5379	275	951	1226	14.0	46.9
9	..	..	..	..	..	..	..	168[5]	168[5]	..	..	..	33	1½	58.3	187	2131	4058	6189	690	1346	2036	10.2	52.5
10	..	..	..	..	..	..	..	168[6]	168[6]	..	..	..	31	3¼	56.3	191	1980	4266	6246	539	1554	2093	12.3	46.4
11	..	..	..	280	..	..	..	224	..	..	560	..	30	3	56.0	158	1880	4104	5984	439	1392	1831	11.3	45.8
12	..	..	280	..	..	..	..	224	..	..	560	..	28	2¼	55.3	264	1842	4134	5976	401	1422	1823	17.8	44.5
13	..	..	..	..	..	..	336[7]	..	..	..	..	..	25	0	56.3	152	1558	3355	4913	117	643	760	12.0	46.4
14	..	..	..	..	..	..	672[8]	..	..	..	..	..	27	1	57.5	176	1743	3696	5439	302	984	1286	16.2	47.1
15	..	..	..	..	224	224	..	224	..	..	..	..	32	3¾	57.5	209	2103	4044	6147	662	1332	1994	11.8	52.0
16	..	..	..	224	..	..	..	56	56	..	560	..	32	3¼	56.3	182	2028	4191	6219	587	1479	2066	11.1	48.4
17	..	..	..	224	..	..	..	112	112	..	280	..	32	0¾	55.8	299	2093	3826	5919	652	1114	1766	15.2	54.7
18	..	..	..	336	..	..	..	112	112	..	..	..	33	0¼	56.5	180	2048	3819	5867	607	1107	1714	11.2	53.6
19	..	..	..	..	112	112	..	112	..	..	336	..	34	3	57.0	133	2114	4215	6329	673	1503	2176	9.1	50.2
20	Unmanured.		..	..	..	..	..	..	..	..	..	..	24	2¾	56.0	113	1495	3104	4599	54	392	446	9.7	48.2
21 } 22	Mixture of the residue of most of the other manures.								..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

[1] The silicate of potass was manufactured at a glass-house, by fusing equal parts of pearl-ash and sand. The product was a transparent glass, slightly deliquescent in the air; it was ground to powder under edge-stones.

The season of 1845 was more favorable for wheat, than that of 1844, and the crops on all the plots were better. On plot No. 3, which had no manure last year, or this, the yield is 23 bushels per acre, against 15 bushels last year.

Last year, the 14 tons of barn-yard manure gave an *increase* of only 5¼ bushels per acre. This year it gives an increase of nearly 9 bushels per acre.

"Do you mean," said the Deacon, "that this plot, No. 2, had 14 tons of manure in 1844, and 14 tons of manure again in 1845?"

"Precisely that, Deacon," said I, "and this same plot has received this amount of manure every year since, up to the present time—for these same experiments are still continued from year to year at Rothamsted."

"It is poor farming," said the Deacon, "and I should think the land would get too rich to grow wheat."

"It is not so," said I, "and the fact is an interesting one, and teaches a most important lesson, of which, more hereafter."

Plot 5, last year, received 700 lbs. of superphosphate per acre. This year, this plot was divided; one half was left without manure, and the other dressed with 252 lbs. of pure carbonate of ammonia per acre. The half without manure, (5*a*), did not produce quite as much grain and straw as the plot which had received no manure for two years in succession. But the wheat was of better quality, weighing 1 lb. more per bushel than the other. Still it is sufficiently evident that superphosphate of lime did no good so far as increasing the growth was concerned, either the first year it was applied, or the year following.

The carbonate of ammonia was dissolved in water and sprinkled over the growing wheat at three different times during the spring. You see this manure, which contains no *mineral* matter at all, gives an increase of nearly 4 bushels of grain per acre, and an increase of 887 lbs. of straw.

"Wait a moment," said the Deacon, "is not 887 lbs. of straw to

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[2] The manures termed superphosphate of lime and phosphate of potass, were made by acting upon bone-ash by means of sulphuric acid, and in the case of the potass salt neutralizing the compound thus obtained, by means of pearl-ash. For the superphoshate of lime, the proportions were, 5 parts bone-ash, 3 parts water, and 3 parts sulphuric acid of sp. gr. 1.84; and for the phosphate of potass, 4 parts bone ash, water as needed, 3 parts sulphuric acid of sp. gr. 1.84; and an equivalent amount of pearl-ash. The mixtures, of course, lost weight considerably by the evolution of water and carbonic acid.

[3] The medicinal carbonate of ammonia; it was dissolved in water and top-dressed.

[4] Plot 5, was 2 lands wide (in after years, respectively, 5*a* and 5*b*); 5^1 consisting of 2 alternate one-fourth lengths across both lands, and 5^2 of the 2 remaining one-fourth lengths.

[5] Top-dressed at once. [6] Top-dressed at 4 intervals. [7] Peruvian. [8] Ichaboe.

4 bushels of grain an unusually large proportion of straw to grain? I have heard you say that 100 lbs. of straw to each bushel of wheat is about the average. And according to this experiment, the carbonate of ammonia produced over 200 lbs. of straw to a bushel of grain. How do you account for this."

"It is a general rule," said I, "that the heavier the crop, the greater is the proportion of straw to grain. On the no-manure plot, we have, this year, 118 lbs. of straw to a bushel of dressed grain. Taking this as the standard, you will find that the *increase* from manures is proportionally greater in straw than in grain. Thus in the increase of barn-yard manure, this year, we have about 133 lbs. of straw to a bushel of grain. I do not believe there is any manure that will give us a large crop of grain without a still larger crop of straw. There is considerable difference, in this respect, between different varieties of wheat. Still, I like to see a good growth of straw."

"It is curious," said the Doctor, "that 3 cwt. of ammonia-salts alone on plots 9 and 10 should produce as much wheat as was obtained from plot 2, where 14 tons of barn-yard manure had been applied two years in succession. I notice that on one plot, the ammonia-salts were applied at once, in the spring, while on the other plot they were sown at four different times—and that the former gave the best results."

The only conclusion to be drawn from this, is, that it is desirable to apply the manure *early* in the spring—or better still, in the autumn.

"You are a great advocate of Peruvian guano," said the Deacon, "and yet 3 cwt of Peruvian guano on Plot 13, only produced an increase of two bushels and 643 lbs. of straw per acre. The guano at $60 per ton, would cost $9.00 per acre. This will not pay."

This is an unusually small increase. The reason, probably, is to be found in the fact that the manure and seed were not sown until March, instead of in the autumn. The salts of ammonia are quite soluble and act quickly; while the Peruvian guano has to decompose in the soil, and consequently needs to be applied earlier, especially on clay land.

"I do not want you," said the Deacon, "to dodge the question why an application of 14 tons of farmyard-manure per acre, every year for over thirty years, does not make the land too rich for wheat."

"Possibly," said I, "on light, sandy soil, such an annual dressing of manure *would* in the course of a few years make the land too rich for wheat. But on a clayey soil, such is evidently not the case. And the fact is a very important one. When we apply manure, our object should be to make it as available as possible. Nature preserves or conserves the food of plants. The object of agriculture is to use the food of plants for our own advantage.

"Please be a little more definite," said the Deacon, "for I must confess I do not quite see the significance of your remarks."

"What he means," said the Doctor, "is this: If you put a quantity of soluble and available manure on land, and do not sow any crop, the manure will not be wasted. The soil will retain it. It will change it from a soluble into a comparatively insoluble form. Had a crop been sown the first year, the manure would do far more good than it will the next year, and yet it may be that none of the manure is lost. It is merely locked up in the soil in such a form as will prevent it from running to waste. If it was not for this principle, our lands would have been long ago exhausted of all their available plant-food."

"I think I understand," said the Deacon; "but if what you say is true, it upsets many of our old notions. We have thought it desirable to plow under manure, in order to prevent the ammonia from escaping. You claim, I believe, that there is little danger of any loss from spreading manure on the surface, and I suppose you would have us conclude that we make a mistake in plowing it under, as the soil renders it insoluble."

"It depends a good deal," said I, "on the character of the soil. A light, sandy soil will not preserve manure like a clay soil. But it is undoubtedly true that our aim in all cases should be to apply manure in such a form and to such a crop as will give us the greatest *immediate* benefit. Plowing under fresh manure every year for wheat is evidently not the best way to get the greatest benefit from it. But this is not the place to discuss this matter. Let us look at the result of Mr. Lawes' experiments on wheat the third year:"

Experiments at Rothamsted on the Growth of

TABLE III.—MANURES AND PRODUCE; 3RD SEASON, 1845-6.

Plots.	Manures per Acre.													
									Superphosph'te of Lime.					
	Farmyard Manure.	*Ash from 3 loads (3,888 lbs.) Wheat-straw.*	*Liebig's Wheat-manure.*	*Peruvian Guano.*	*Silicate of Potass.*	*Pearl-ash.*	*Soda-ash.*	*Magnesian Lime-stone.*	*Bone-ash.*	*Sulphuric Acid (Sp. gr. 1·7.)*	*Muriatic Acid.*	*Sulphate of Ammonia.*	*Muriate of Ammonia.*	*Rape-Cake.*
	Tons.		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
0	..	..	..	336	..	..	..	..	..	..	..	..	..	..
1	..	..	..	..	..	..	..	..	224	..	..	..	..	..
2	14	..	..	..	..	..	..	..	..	..	..	..	..	..
3	Unmanured.		..	..	..	..	..	..	..	..	..	..	..	..
4	..	..	..	..	..	..	..	..	224	..	224	224	..	..
5a 1	..	Straw Ash.	..	..	..	..	..	..	..	..	..	..	..	..
5a 2	..		..	..	..	..	..	..	..	..	..	224[1]	..	..
5b 1	..		..	..	..	..	..	..	..	..	..	..	..	448
5b 2	..		..	..	..	..	..	..	..	..	..	224[1]	..	448
6a	..	..	448	..	..	..	..	..	..	..	..	..	..	..
6b	..	..	448	..	..	..	..	..	..	..	..	112	112	..
7a	..	..	448	..	..	..	..	..	..	..	..	..	..	448
7b	..	..	448	..	..	..	..	..	..	..	..	112	112	448
8a	..	..	..	..	..	..	..	..	224	..	..	..	..	448
8b	..	..	..	..	..	..	..	..	224	..	..	112	112	..
9a	..	..	..	..	..	..	..	..	..	..	..	..	..	448
9b	..	..	..	..	..	..	..	..	..	..	..	224	..	448
10a	..	..	..	..	..	..	..	..	..	..	..	224	..	..
10b	Unmanured.		..	..	..	..	..	..	..	..	..	..	..	..
11a	..	..	..	..	..	..	..	..	224	224	..	..	..	448
11b	..	..	..	..	..	..	..	..	224	224	..	112	112	..
12a	..	..	..	..	..	..	180	..	224	224	..	..	..	448
12b	..	..	..	..	..	..	180	..	224	224	..	112	112	..
13a	..	..	..	..	..	200	..	..	224	224	..	..	..	448
13b	..	..	..	..	..	200	..	..	224	224	..	112	112	..
14a	..	..	..	..	..	..	..	84	224	224	..	..	..	448
14b	..	..	..	..	..	..	..	84	224	224	..	112	112	..
15a	..	..	..	..	..	..	..	..	224	..	224	224	..	448
15b	..	..	..	..	224	..	..	..	224	..	224	224	..	448
16a	..	..	..	..	..	67	60	84	224	224	..	..	..	448
16b	..	..	..	..	..	67	60	84	224	224	..	224	..	448
17a	..	..	..	..	..	67	60	84	224	224	..	112	112	448
17b	..	..	..	..	..	67	60	84	224	224	..	224	..	..
18a	..	..	..	..	..	67	60	84	224	224	..	112	112	..
18b	..	..	..	..	..	67	60	84	224	224	..	..	..	..
19	..	..	..	..	..	..	..	..	112	..	112	112	..	448
20, 21, 22	Mixture of the residue of most of the other manures.										..	..	..	..

[1] Top-dressed in the Spring.

Wheat, Year after Year, on the same Land.

MANURES AND SEED (OLD RED LAMMAS), SOWN AUTUMN, 1845.

Plots.	Produce per Acre, etc.							Increase ℔ Acre by Manure.			Offal Corn to 100 Dressed.	Corn to 100 Straw.
	Dressed Corn.			Offal Corn.	Total Corn.	Straw and Chaff.	Total Produce (Corn and Straw).	Corn.	Straw and Chaff.	Total Produce.		
	Quantity.		Weight per Bushel.									
	Bush.	P'cks.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.		
0	28	1¾	62.3	134	1906	2561	4467	699	1048	1747	7.3	74.4
1	22	0¾	62.6	120	1509	1953	3462	302	440	742	8.1	77.3
2	27	0¾	63.0	113	1826	2454	4280	619	941	1560	6.6	74.4
3	17	3¾	63.8	64	1207	1513	2720	..	..	..	7.4	79.7
4	25	3¾	63.5	130	1777	2390	4167	570	877	1447	7.8	74.3
5a { 1	19	0¼	63.7	87	1305	1541	2846	98	28	126	..	84.6
5a { 2	27	0	63.0	126	1827	2309	4136	620	796	1416	..	79.1
5b { 1	23	2½	63.4	100	1598	1721	3319	391	208	599	..	92.8
5b { 2	30	0¾	63.3	165	2076	2901	4977	869	1388	2257	..	71.6
6a	20	1½	63.7	102	1400	1676	3076	193	163	356	7.0	83 6
6b	29	0¾	63.5	114	1967	2571	4538	760	1058	1818	5.3	76.5
7a	22	3¼	63.0	97	1534	1968	3502	327	405	732	6.8	77.9
7b	31	3	63.4	150	2163	3007	5170	956	1494	2450	7.5	72.6
8a	22	3¼	63.5	101	1549	1963	3512	342	450	792	7.1	78.9
8b	29	0¾	63.6	132	1988	2575	4563	781	1062	1843	7.2	77.2
9a	23	2¾	63.0	122	1614	2033	3647	407	520	927	7.9	79.4
9b	28	3½	63.3	114	1942	2603	4545	735	1090	1825	7.0	74.6
10a	27	1½	63.6	109	1850	2244	4094	643	731	1374	6.4	82.4
10b	17	2¼	63.8	92	1216	1455	2671	9	—58	—49	7.8	83.6
11a	23	1¾	63.3	145	1628	2133	3761	421	620	1041	9.8	76.3
11b	30	0½	63.2	155	2055	2715	4770	848	1202	2050	6.1	75.7
12a	24	1½	63.0	125	1661	2163	3824	454	650	1104	7.9	76.8
12b	28	2¾	63.4	136	1955	2554	4509	748	1041	1789	7.4	76.5
13a	24	0	63.5	136	1660	2327	3987	453	814	1267	9.1	71.3
13b	29	1¾	63.2	138	1998	2755	4753	791	1242	2033	7.3	72.5
14a	23	2½	63.0	117	1605	2031	3636	398	518	916	7.7	79.0
14b	26	2¼	63.4	124	1812	2534	4356	605	1021	1626	7.4	71.5
15a	31	1¾	62.5	147	2112	2936	5048	905	1423	2328	7.5	71.9
15b	27	2¾	63.0	117	1861	2513	4374	654	1000	1654	5.9	74.0
16a	23	3	62.5	108	1592	2067	3659	385	554	939	7.0	77.0
16b	30	1	62.7	122	2019	2836	4855	812	1323	2135	6.6	71.2
17a	33	2¾	62.8	129	2241	3278	5519	1034	1765	2799	5.8	68.3
17b	30	2	63.0	113	2034	2784	4818	827	1271	2098	5.9	73.0
18a	31	0	62.8	103	2048	2838	4886	841	1325	2166	5.1	72.2
18b	21	1	62.0	157	1474	1893	3367	267	380	647	6.6	77.1
19	28	3	62.0	107	1889	2425	4314	682	912	1594	5.8	77.9
20, 21, 22	..	..	..	..	..	..	..	..	..	..	..	..

This year, the seed and manures were sown in the autumn. And I want the Deacon to look at plot 0. 3 cwt. of Peruvian guano here gives an increase of 10½ bushels of wheat, and 1,048 lbs. of straw per acre. This will pay *well*, even on the wheat alone. But in addition to this, we may expect, in our ordinary rotation of crops, a far better crop of clover where the guano was used.

In regard to some of the results this year, Messrs. Lawes and Gilbert have the following concise and interesting remarks:

"At this third experimental harvest, we have on the continuously unmanured plot, namely, No. 3, not quite 18 bushels of dressed corn, as the normal produce of the season; and by its side we have on plot 10*b*—comprising one-half of the plot 10 of the previous years, and so highly manured by ammoniacal salts in 1845, but now unmanured—rather more than 17½ bushels. The near approach, again, to identity of result from the two unmanured plots, at once gives confidence in the accuracy of the experiments, and shows us how effectually the preceding crop had, in a practical point of view, reduced the plots, previously so differently circumstanced both as to manure and produce, to something like an uniform standard as regards their grain-producing qualities.

"Plot 2 has, as before, 14 tons of farm-yard manure, and the produce is 27¼ bushels, or between 9 and 10 bushels more than without manure of any kind.

"On plot 10*a*, which in the previous year gave by ammoniacal salts alone, a produce equal to that of the farm-yard manure, we have again a similar result: for two cwts. of sulphate of ammonia has now given 1,850 lbs. of total corn, instead of 1,826 lbs., which is the produce on plot 2. The straw of the latter, is, however, slightly heavier than that by the ammoniacal salt.

"Again, plot 5*a*, which was in the previous season *unmanured*, was now subdivided: on one-half of it (namely, $5a^1$) we have the ashes of wheat-straw alone, by which there is an increase of rather more than one bushel per acre of dressed corn; on the other half (or $5a^2$) we have, besides the straw-ashes, two cwts. of sulphate of ammonia put on as a top-dressing: two cwts. of sulphate of ammonia have, in this case, only increased the produce beyond that of $5a^1$ by 7⅝ bushels of corn and 768 lbs. of straw, instead of by 9¾ bushels of corn and 789 lbs. of straw, which was the increase obtained by the same amount of ammoniacal salt on 10*a*, as compared with 10*b*.

"It will be observed, however, that in the former case the ammoniacal salts were top-dressed, but in the latter they were drilled at the time of sowing the seed; and it will be remembered that in

1845 the result was better *as to corn* on plot 9, where the salts were sown earlier, than on plot 10, where the top-dressing extended far into the spring. We have had several direct instances of this kind in our experience, and we would give it as a suggestion, in most cases applicable, that manures for wheat, and especially ammoniacal ones, should be applied before or at the time the seed is sown; for, although the apparent luxuriance of the crop is greater, and the produce of straw really heavier, by spring rather than autumn sowings of Peruvian guano and other ammoniacal manures, yet we believe that that of the *corn* will not be increased in an equivalent degree. Indeed, the success of the crop undoubtedly depends very materially on the progress of the underground growth during the winter months; and this again, other things being equal, upon the quantity of available nitrogenous constituents within the soil, without a liberal provision of which, the range of the fibrous feeders of the plant will not be such, as to take up the minerals which the soil is competent to supply, and in such quantity as will be required during the after progress of the plant for its healthy and favorable growth."

These remarks are very suggestive and deserve special attention. "The next result to be noticed," continue Messrs. Lawes and Gilbert, "is that obtained on plot 6, now also divided into two equal portions designated respectively 6*a* and 6*b*. Plot No. 6 had for the crop of 1844, superphosphate of lime and the phosphate of magnesia manure, and for that of 1845, superphosphate of lime, rape-cake, and ammoniacal salts. For this, the third season, it was devoted to the trial of the wheat-manure manufactured under the sanction of Professor Liebig, and patented in this country.

"Upon plots 6*a*, four cwts. per acre of the patent wheat-manure were used, which gave 20¼ bushels, or rather more than two bushels beyond the produce of the unmanured plot; but as the manure contained, besides the minerals peculiar to it, some nitrogenous compounds, giving off a very perceptible odor of ammonia, some, at least, of the increase would be due to that substance. On plot 6*b*, however, the further addition of one cwt. each of sulphate and muriate of ammonia to this so-called 'Mineral Manure,' gives a produce of 29¼ bushels. In other words, the addition of ammoniacal salt, to Liebig's mineral manure has increased the produce by very nearly 9 bushels per acre beyond that of the mineral manure alone, whilst the increase obtained over the unmanured plot, by 14 tons of farm-yard manure, was only 9¼ bushels!

The following table gives the results of the experiments the *fourth* year, 1846-7.

EXPERIMENTS AT ROTHAMSTED ON THE GROWTH OF

TABLE IV.—MANURES AND PRODUCE; 4TH SEASON, 1846–7.

Plots.	MANURES PER ACRE.							
	Farm-yard Manure.	Peruvian Guano.	Superphosphate of Lime.			Sulphate of Ammonia.	Muriate of Ammonia.	Rice.
			Bone-ash.	Sulphuric Acid (Sp. gr. 1.7).	Muriatic Acid.			
	Tons.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
0	..	500	..	..	..	..	..	..
1	..	..	200	..	200	350	50	..
2	14	..	..	..	..	..	..	..
3	Unmanured.		..	..	..	..	..	..
4	..	..	200	..	200	300	..	..
5a	..	..	200	200	..	150	150	..
5b	..	..	200	200	..	150	150	500
6a	..	..	..	..	..	150	150	..
6b	..	..	..	..	..	150	150	..
7a	..	..	..	..	..	150	150	..
7b	..	..	..	..	..	150	150	..
8a	..	..	200	200	..	150	150	500
8b	..	..	200	200	..	200	200	..
9a { 1	..	.	..	..	..	..	..	2240
9a { 2	..	..	..	..	..	150	150	..
9b	..	..	..	..	..	150	150	..
10a	..	..	..	..	..	150	150	..
10b	..	..	..	..	..	150	150	..
11a	..	..	100	100	..	150	150	..
11b	..	..	100	100	..	150	150	..
12a	..	..	100	100	..	150	150	..
11b	..	..	100	100	..	150	150	.
13a	..	..	100	100	..	150	150	..
13b	..	..	100	100	..	150	150	..
14a	..	..	100	100	..	150	150	..
14b	..	..	100	100	..	150	150	..
15a	..	..	200	..	200	300	..	500
15b	..	..	200	..	200	300	..	500
16a	..	..	100	100	..	150	150	..
16b	..	..	100	100	..	150	150	..
17a	..	..	100	100	..	150	150	..
17b	..	..	100	100	..	200	200	..
18a	..	..	100	100	..	150	150	..
18b	..	..	100	100	..	150	150	..
19	..	..	100	..	100	300	..	500
20	Unmanured.		..	..	..	..	..	..
21 } 22 }	Mixture of the residue of most of the other manures.						..	..

WHEAT, YEAR AFTER YEAR, ON THE SAME LAND.

MANURES AND SEED (OLD RED LAMMAS), SOWN END OF OCTOBER, 1846.

Plots.	Produce per Acre, &c.							Increase ℔ Acre by Manure.			*Offal Corn to 100 Dressed.*	*Corn to 100 Straw.*
	Dressed Corn.											
	Quantity.		*Weight per Bushel.*	*Offal Corn.*	*Total Corn.*	*Straw and Chaff.*	*Total Produce (Corn and Straw.)*	*Corn.*	*Straw and Chaff.*	*Total Produce.*		
	Bush.	P'cks.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.		
0	30	2¾	61.1	156	2031	3277	5308	908	1375	2283	8.2	61.9
1	32	1	61.2	147	2119	3735	5854	996	1833	2829	7.2	56.7
2	29	3¾	62.3	117	1931	3628	5609	858	1726	2584	6.2	54.6
3	16	3½	61.0	95	1123	1902	3025	..	..	..	8.9	59.0
4	27	1¾	61.9	82	1780	2948	4728	657	1046	1703	4.7	60.3
5a	29	0	61.8	130	1921	3412	5333	798	1510	2309	7.1	56.3
5b	32	2	61.4	136	2132	3721	5853	1009	1819	2827	6.6	57.2
6a	24	3¼	62.1	122	1663	2786	4449	540	884	1424	7.8	59.6
6b	24	1¾	61.6	127	1632	2803	4435	509	901	1410	8.2	58.2
7a	27	3¼	61.7	118	1834	3151	4985	711	1249	1960	6.8	58.2
7b	25	1¼	61.5	125	1682	2953	4635	559	1051	1610	7.9	56.9
8a	32	1¾	62.1	102	2115	3683	5798	992	1781	2773	5.5	57.4
8b	30	3	61.7	123	2020	3720	5740	897	1818	2715	6.3	54.3
9a { 1	22	3	62.5	..	1477	2506	3983	228	604	..	..	53.9
9a { 2	26	2	61.0	..	1755	3052	4807	632	1150	..	..	57.5
9b	26	0	61.3	123	1717	2858	4575	594	956	1550	..	60.1
10a	25	3	61.5	118	1702	2891	4593	579	989	1568	7.3	58.8
10b	25	2¾	61.2	133	1705	2874	4579	582	972	1554	8.2	59.3
11a	30	3½	61.6	142	2044	3517	5561	921	1615	2536	6.3	59.5
11b	29	1¾	61.8	123	1941	3203	5144	818	1301	2119	6.7	60.6
12a	29	2	62.0	124	1953	3452	5405	830	1550	2380	6.6	57.1
12b	27	0¼	61.8	121	1796	3124	4920	673	1222	1895	7.1	57 4
13a	29	2½	62.5	108	1959	3306	5265	836	1404	2240	5.5	57.3
13b	27	1½	62.3	96	1801	3171	4972	678	1269	1947	5.3	56.7
14a	28	0¾	62.8	175	1944	3362	5306	821	1460	2281	9.7	59.5
14b	26	3¾	62.8	166	1856	3006	4862	733	1104	1837	9.8	61.7
15a	32	3	63.0	151	2214	3876	6090	1091	1974	3065	7.2	57.1
15b	32	0	62.6	137	2140	3617	5757	1017	1715	2732	6.6	59.1
16a	29	1¼	62.3	132	1959	3417	5376	836	1515	2351	6.9	57.3
16b	34	2¼	62.6	119	2283	4012	6295	1160	2110	3270	5.2	56.9
17a	33	3	62.3	119	2222	4027	6249	1099	2125	3224	5.6	55.1
17b	35	1¾	62.0	117	2314	4261	6575	1191	2359	3550	6.4	54.3
18a	32	0¾	62.7	142	2160	3852	6012	1037	1950	2987	6.9	56.0
18b	29	1½	62.9	181	2029	4164	6193	906	2262	3168	9.7	48.7
19	32	3	62.8	140	2195	4202	6397	1072	2300	3372	6.7	52.2
20	20	0¾	62.5	70	1332	2074	3406	209	172	381	4.9	64.2
21 } 22 }	..	..	..	..	..	..	..	..	..	..	..	..

Here again, I want the Deacon to look at plot 0, where 500 lbs. Peruvian guano, sown in October, gives an *increase* of nearly 14 bushels of dressed wheat and 1,375 lbs. of straw per acre. On plot 2, where 14 tons of barn-yard manure have now been applied four years in succession (56 tons in all), there is a little more straw, but not quite so much grain, as from the 500 lbs. of guano.

"But will the guano," said the Deacon, "be as lasting as the manure?"

"Not for wheat," said I. "But if you seed the wheat down with clover, as would be the case in this section, we should get considerable benefit, probably, from the guano. If wheat was sown after the wheat, the guano applied the previous season would do little good on the second crop of wheat. And yet it is a matter of fact that there would be a considerable proportion of the guano left in the soil. The wheat cannot take it up. But the clover can. And we all know that if we can grow good crops of clover, plowing it under, or feeding it out on the land, or making it into hay and saving the manure obtained from it, we shall thus be enabled to raise good crops of wheat, barley, oats, potatoes, and corn, and in this sense guano is a 'lasting' manure."

"Barnyard-manure," said the Doctor, "is altogether too 'lasting.' Here we have had 56 tons of manure on an acre of land in four years, and yet an acre dressed with 500 lbs. of guano produces just as good a crop. The manure contains far more plant-food, of all kinds, than the guano, but it is so 'lasting' that it does not do half as much good as its composition would lead us to expect. Its 'lasting' properties are a decided objection, rather than an advantage. If we could make it less lasting—in other words, if we could make it act quicker, it would produce a greater effect, and possess a greater value. In proportion to its constituents, the barn-yard manure is far cheaper than the guano, but it has a less beneficial effect, because these constituents are not more completely decomposed and rendered available."

"That," said I, "opens up a very important question. We have more real value in manure than most of us are as yet able to bring out and turn to good account. The sandy-land farmer has an advantage over the clay-land farmer in this respect. The latter has a naturally richer soil, but it costs him more to work it, and manure does not act so rapidly. The clay-land farmer should use his best endeavors to decompose his manure."

"Yes," said the Doctor, "and, like John Johnston, he will probably find it to his advantage to use it largely as a top-dressing on the surface. Exposing manure to the atmosphere, spread out on the land for several months, and harrowing it occasionally, will do much to render its constituents available. But let us return to Mr. Lawes' wonderful experiments."

"On eight plots," said I, "300 lbs. of ammonia-salts were used without any other manures, and the *average* yield on these eight plots was nearly 26 bushels per acre, or an average increase of 9 bushels per acre. The same amount of ammonia-salts, with the addition of superphosphate of lime, gave an increase of 13 bushels per acre. 400 lbs. ammonia-salts, with superphosphate of lime, gave an *increase* of nearly 16 bushels per acre, or three bushels per acre more than where 14 tons of barn-yard manure had been used four years in succession.

"I hope, after this, the Deacon will forgive me for dwelling on the value of available nitrogen or ammonia as a manure for wheat."

"I see," said the Deacon, "that ground *rice* was used this year for manure; and in 1845, *tapioca* was also used as a manure. The Connecticut Tobacco growers a few years since used *corn-meal* for manure, and you thought it a great waste of good food."

I think so still. But we will not discuss the matter now. Mr. Lawes wanted to ascertain whether *carbonaceous* matter was needed by the growing wheat-plants, or whether they could get all they needed from the soil and the atmosphere. The enormous quantities of carbonaceous matter supplied by the barn-yard manure, it is quite evident, are of little value as a manure for wheat. And the rice seems to have done very little more good than we should expect from the 22 lbs. of nitrogen which it contained. The large quantity of carbonaceous matter evidently did little good. Available carbonaceous matter, such as starch, sugar, and oil, was intended as food for man and beast—not as food for wheat or tobacco.

The following table gives the results of the experiments the *fifth* year, 1847-8.

EXPERIMENTS AT ROTHAMSTED ON THE GROWTH OF

TABLE V.—MANURES AND PRODUCE; 5TH SEASON, 1847–8.

Plots.	MANURES PER ACRE.										
						Superphosphate of Lime.					
	Farm-yard Manure.	*Pearl-ash.*	*Soda-ash.*	*Sulphate of Magnesia.*	*Superphosphate of Lime.*	*Bone-ash.*	*Sulphuric Acid (Sp. gr. 1.7.)*	*Muriatic Acid.*	*Sulphate of Ammonia.*	*Muriate of Ammonia.*	*Rape-Cake.*
	Tons.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
0	..	..	..	..	2240	..	..	..	..	..	..
1	..	..	..	..	..	..	..	..	..	..	..
2	14	..	..	..	..	..	..	..	..	..	..
3	Unmanured.		..	..	..	..	..	..	..	..	..
4	..	..	..	..	..	200	..	200	300	..	..
5*a*	..	300	200	100	..	200	150	..	250	250	..
5*b*	..	300	200	100	..	200	150	..	200	200	500
6*a*	..	..	..	..	..	400	300	..	200	200	..
6*b*	..	..	..	..	..	200	150	..	200	200	..
7*a*	..	..	..	..	..	400	300	..	150	150	500
7*b*	..	..	..	..	..	200	150	..	150	150	500
8*a*	..	300	200	100	..	200	150	..	..	..	..
8*b*	..	300	200	100	..	200	150	..	..	..	..
9*a*	..	..	..	..	..	200	150	..	..	..	..
9*b*	..	..	..	..	..	200	150	..	150	150	..
10*a*	..	..	..	..	..	..	..	..	150	150	..
10*b*	..	300	200	100	..	200	150	..	150	150	..
11*a*	..	..	..	..	..	200	150	..	150	150	500
11*b*	..	..	..	..	..	200	150	..	200	200	..
12*a*	..	300	..	..	..	200	150	..	150	150	500
12*b*	..	300	..	..	..	200	150	..	200	200	..
13*a*	..	300	..	..	..	200	150	..	150	150	500
13*b*	..	300	..	..	..	200	150	..	200	200	..
14*a*	..	300	..	..	..	200	150	..	150	150	500
14*b*	..	300	..	..	..	200	150	..	200	200	..
15*a*	..	300	200	100	..	200	..	200	300	..	..
15*b*	..	300	200	100	..	200	..	200	300	..	..
16*a*	..	300	200	100	..	200	150	..	150	150	500
16*b*	..	300	200	100	..	200	150	..	150	150	500
17*a*	..	300	200	100	..	200	150	..	200	200	..
17*b*	..	300	200	100	..	200	150	..	200	200	..
18*a*	..	300	200	100	..	200	150	..	150	150	..
18*b*	..	300	200	100	..	200	150	..	150	150	..
19	..	..	..	..	..	200	..	200	300	..	500
20	Unmanured.		..	..	..	.	..	..	..	..	..
21	..	..	..	..	..	..	..	..	..	..	..
22											

Wheat, Year after Year, on the same Land.

MANURES AND SEED (OLD RED LAMMAS) SOWN AUTUMN, 1847.

Plots.	Produce per Acre, etc. — Dressed Corn. — Quantity.		Dressed Corn. — Weight per Bushel.	Offal Corn.	Total Corn.	Straw and Chaff	Total Produce (Corn and Straw.)	Increase ℔ Acre by Manure. — Corn.	Straw and Chaff.	Total Produce.	Offal Corn to 100 Dressed.	Corn to 100 Straw.
	Bush.	Pks.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.		
0	19	0¾	53.4	138	1259	2074	3333	307	362	669	13.4	60.7
1	16	0¾	59.6	160	1124	1735	2859	172	23	195	16.3	64.7
2	25	2¾	58.2	210	1705	3041	4746	753	1329	2082	13.8	56.0
3	14	3	57.3	106	952	1712	2664	..	..	..	12.1	55.6
4	24	0½	58.5	172	1583	2713	4296	631	1001	1632	12.0	58.3
5a	29	3½	59.2	144	1911	3266	5177	959	1554	2513	7.9	58.5
5b	30	3½	59.1	107	1932	3533	5465	980	1821	2801	5.8	57.5
6a	24	3¼	58.8	214	1672	2878	4550	720	1166	1886	14.6	58.0
6b	26	3	56.9	216	1737	2968	4705	785	1256	2041	14.0	58.5
7a	30	3¼	59.4	106	1936	3088	5024	984	1376	2360	5.7	62.6
7b	29	3¼	59.6	187	1963	3413	5376	1011	1701	2712	10.3	57.5
8a	19	3	56.2	154	1263	2317	3580	311	605	916	13.6	54.5
8b	19	0¾	59.4	127	1267	2148	3415	315	436	751	11.1	58.8
9a	18	2½	56.7	125	1181	1945	3126	229	233	462	11.6	60.7
9b	25	0¼	58.3	208	1669	2918	4587	717	1206	1923	13.9	57.1
10a	19	1	58.1	215	1334	2367	3701	382	655	1037	19.0	56.3
10b	25	0¼	57.8	155	1604	2926	4530	652	1214	1866	10.6	54.8
11a	29	1½	59.6	233	1984	3274	5258	1032	1562	2594	13.1	60.6
11b	24	3	57.9	207	1641	2898	4539	689	1186	1875	14.1	56.4
12a	29	3	59.3	174	1938	3390	5328	986	1678	2664	9.3	57.2
12b	26	0¾	59.2	167	1717	2880	4597	765	1168	1933	10.7	59.6
13a	29	1½	57.9	253	1955	3290	5245	1003	1578	2581	14.7	59.4
13b	25	3¼	58.4	224	1730	3072	4802	778	1360	2138	14.6	56.3
14a	28	0½	58.8	184	1834	3257	5091	882	1545	2427	11.1	56.3
14b	25	2½	58.5	227	1726	2897	4623	774	1185	1959	15.1	59.5
15a	22	3½	58.1	242	1571	2937	4508	619	1225	1844	18.1	53.4
15b	24	2¾	56.9	202	1607	3016	4623	655	1304	1959	14.1	53.2
16a	29	3¼	60.0	184	1973	3115	5088	1021	1403	2424	10.2	63.3
16b	30	1¾	58.4	171	1948	3380	5328	996	1668	2664	9.4	57.6
17a	27	2½	59.7	285	1933	3296	5229	981	1584	2565	17.0	58.6
17b	28	3½	59.7	222	1946	3324	5270	994	1612	2606	12.6	58.5
18a	26	3	59.2	150	1734	2935	4669	782	1223	2005	9.2	59.0
18b	26	2¾	59.6	215	1804	3056	4860	852	1344	2196	13.3	58.7
19	29	1¾	56.2	185	1838	3295	5133	886	1583	2469	10.4	55.7
20	16	0½	58.3	111	1050	1721	2771	98	9	107	11.3	61.0
21 } 22 }	..	..	..	..	..	..	..	..	..	..	..	..

This season was considered unfavorable for wheat. The continuously unmanured plot produced 14¾ bushels, and the plot receiving 14 tons of barn-yard manure, 25¾ bushels per acre nearly.

300 lbs. of ammonia-salts alone on plot 10*a*, gave 19¼ bushels per acre, while the same quantity of ammonia, with superphosphate in addition, gave, on plot 9*b*, 25 bushels per acre.

The addition to the above manures of 300 lbs. of potash, 200 lbs. soda, and 100 lbs. sulphate of magnesia, on plot 10*b*, gave precisely the same yield per acre as the ammonia and the superphosphate alone. *The potash, soda, and magnesia, therefore, did no good.*

400 lbs. of ammonia-salts, with superphosphate, potash, etc., gave, on plot 17*b*, nearly 29 bushels per acre, or 3½ bushels more than the plot which has now received 70 tons of barn-yard manure in five successive years.

"I see that, on plot 0," said the Deacon, "one ton of superphosphate was used per acre, and it gave only half a bushel per acre more than 350 lbs. on 9*a*."

"This proves," said I, "that an excessive dose of superphosphate will do no harm. I am not sure that 100 lbs. of a good superphosphate *drilled in with the seed*, would not have done *as much good* as a ton per acre."

"You say," remarked the Deacon, "that the season was unfavorable for wheat. And yet the no-manure plot produced nearly 15 bushels of wheat per acre."

"That is all true," said I, "and yet the season was undoubtedly an unfavorable one. This is shown not only in the less yield, but in the inferior quality of the grain. The 'dressed corn' on the no-manure plot this year only weighed 57⅓ lbs. per bushel, while last year it weighed 61 lbs. per bushel."

"By the way," said the Doctor, "what do Messrs. Lawes and Gilbert mean by 'dressed corn'?"

"By 'corn,'" said I, "they mean wheat; and by 'dressed corn' they mean wheat that has been run through a fanning-mill until all the light and shrunken grain is blown or sieved out. In other words, 'dressed corn' is wheat carefully cleaned for market. The English farmers take more pains in cleaning their grain than we do. And this 'dressed corn' was as clean as a good fanning-mill could make it. You will observe that there was more 'offal corn' this year than last. This also indicates an unfavorable season."

"It would have been very interesting," said the Doctor, "if Messrs. Lawes and Gilbert had analyzed the wheat produced by the different manures, so that we might have known something in regard to the quality of the flour as influenced by the use of different fertilizers."

"They did that very thing," said I, "and not only that, but they made the wheat grown on different plots, into flour, and ascertained the yield of flour from a given weight of wheat, and the amount of bran, middlings, etc., etc. They obtained some very interesting and important results. I was there at the time. But this is not the place to discuss the question. I am often amused, however, at the remarks we often hear in regard to the inferior quality of our wheat as compared to what it was when the country was new. Many seem to think that 'there is something lacking in the soil'—some say potash, and some phosphates, and some this, and some that. I believe nothing of the kind. Depend upon it, the variety of the wheat and the soil and season have much more to do with the quality or strength of the flour, than the chemical composition of the manures applied to the land."

"At any rate," said the Doctor, "we may be satisfied that anything that will produce a vigorous, healthy growth of wheat is favorable to quality. We may use manures in excess, and thus produce over-luxuriance and an unhealthy growth, and have poor, shrunken grain. In this case, it is not the use, but the abuse of the manure that does the mischief. We must not manure higher than the season will bear. As yet, this question rarely troubles us. Hitherto, as a rule, our seasons are better than our farming. It may not always be so. We may find the liberal use of manure so profitable that we shall occasionally use it in excess. At present, however, the tendency is all the other way. We have more grain of inferior quality from lack of fertility than from an excess of plant-food."

"That may be true," said I, "but we have more poor, inferior wheat from lack of draining and good culture, than from lack of plant-food. Red-root, thistles, cockle, and chess, have done more to injure the reputation of 'Genesee Flour,' than any other one thing, and I should like to hear more said about thorough cultivation, and the destruction of weeds, and less about soil exhaustion."

The following table shows the results of the experiments the *sixth year*, 1848–9.

EXPERIMENTS AT ROTHAMSTED ON THE GROWTH OF

TABLE VI.—MANURES AND PRODUCE; 6TH SEASON, 1848-9.

Plots.	Manures per Acre.									
					Superphosphate of Lime.					
	Farm-yard Manure.	*Pearl-ash.*	*Soda-ash.*	*Sulphate of Magnesia.*	*Bone-ash.*	*Sulphuric Acid. (Sp. gr. 1.7)*	*Muriatic Acid.*	*Sulphate of Ammonia.*	*Muriate of Ammonia.*	*Rape-cake.*
	Tons.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
0	..	..	..	..	600	450	..	..	..	..
1	..	600	400	200	..	..	..	..	..	..
2	14	..	..	..	..	..	..	..	..	..
3	Unmanured.		..	..	..	..	..	..	..	..
4	..	..	..	..	200	..	200	300	..	..
5*a*	..	300	200	100	200	150	..	250	250	..
5*b*	..	300	200	100	200	150	..	200	200	500
6*a*	..	300	200	100	200	150	..	200	200	..
6*b*	..	300	200	100	200	150	..	200	200	..
7*a*	..	300	200	100	200	150	..	200	200	..
7*b*	..	300	200	100	200	150	..	200	200	..
8*a*	Unmanured.		..	..	..	..	..	..	..	..
8*b*	..	..	..	..	..	..	..	..	..	2000
9*a*	..	..	..	..	..	..	..	..	..	2000
9*b*	Unmanured.		..	..	..	..	..	..	..	..
10*a*	..	..	..	..	..	..	..	200	200	..
10*b*	..	..	..	..	..	..	..	200	200	..
11*a*	..	..	..	..	200	150	..	200	200	..
11*b*	..	..	..	..	200	150	..	200	200	..
12*a*	..	300	..	..	200	150	..	200	200	..
12*b*	..	300	..	..	200	150	..	200	200	..
13*a*	..	300	..	..	200	150	..	200	200	..
13*b*	..	300	..	..	200	150	..	200	200	..
14*a*	..	300	..	..	200	150	..	200	200	..
14*b*	..	300	..	..	200	150	..	200	200	..
15*a*	..	300	200	100	200	..	200	300	..	..
15*b*	..	300	200	100	200	..	200	300	..	500
16*a*	..	300	200	100	200	150	..	200	200	..
16*b*	..	300	200	100	200	150	..	200	200	..
17*a*	..	300	200	100	200	150	..	200	200	..
17*b*	..	300	200	100	200	150	..	200	200	..
18*a*	..	300	200	100	200	150	..	200	200	..
18*b*	.	300	200	100	200	150	..	200	200	..
19	..	..	..	..	200	..	200	300	..	500
20	Unmanured.		..	..	..	..	..	..	..	..
21 } 22 }	Mixture of the residue of most of the other manures.								..	..

WHEAT, YEAR AFTER YEAR, ON THE SAME LAND.

MANURES AND SEED (RED CLUSTER), SOWN AUTUMN, 1848.

Plots.	Produce per Acre, etc.							Increase ℔ Acre by Manure.			*Offal Corn to 100 Dressed.*	*Corn to 100 Straw.*
	Dressed Corn.			*Offal Corn.*	*Total Corn.*	*Straw and Chaff.*	*Total Produce (Corn and Straw).*	*Corn.*	*Straw and Chaff.*	*Total Produce.*		
	Quantity.		*Weight per Bushel.*									
	Bush.	Pks.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.		
0	..	..	..	..	..	..	..	..	..	..	..	..
1	..	..	..	..	..	..	..	..	..	..	..	..
2	31	0	63.8	107	2068	3029	5097	839	1415	2254	4.7	68.3
3	19	1	61.4	47	1229	1614	2843	..	..	..	3.9	76.1
4	30	0	63.0	110	2063	2645	4708	834	1031	1865	5.6	78.0
5*a*	37	1¼	63.1	89	2446	3589	6035	1217	1975	3192	3.7	68.1
5*b*	39	3½	63.4	97	2651	3824	6475	1422	2210	3632	5.0	69.3
6*a*	36	1½	63.0	117	2410	3072	5482	1181	1458	2639	5.1	78.4
6*b*	37	3¾	63.0	94	2484	3516	6000	1255	1902	3157	3.9	70.6
7*a*	38	2¼	63 1	137	2576	3584	6160	1347	1970	3317	5.6	71.9
7*b*	37	3¾	62.9	141	2531	3396	5927	1302	1782	3084	5.9	74.5
8*a*	22	3	61.7	76	1481	1815	3296	252	201	453	5.3	81.6
8*b*	31	2½	63.0	85	2080	3166	5246	851	1552	2403	4.3	65.7
9*a*	30	2¾	62.8	111	2035	2683	4718	806	1069	1875	5.8	75.8
9*b*	22	1½	62.3	80	1475	1810	3285	246	196	432	5.7	81.5
10*a*	32	2¼	62.3	112	2141	2851	4992	912	1237	2149	5.5	75.1
10*b*	32	1¼	63.3	110	2157	2960	5117	928	1346	2274	5.3	72.9
11*a*	35	0½	62.6	121	2317	2892	5209	1088	1278	2366	5.6	80.1
11*b*	32	1¼	63.0	112	2149	2942	5091	920	1328	2248	5.5	73.0
12*a*	35	3¼	64.3	93	2396	3371	5767	1167	1757	2924	4.1	71.1
12*b*	34	1¼	64.3	71	2277	3300	5577	1048	1687	2735	3.2	69.0
13*a*	34	3¾	64.1	101	2340	3236	5576	1111	1622	2733	4.5	72.3
13*b*	34	2¼	64.1	129	2346	3246	5592	1117	1632	2749	5.8	72.3
14*a*	34	1½	64.3	56	2266	3211	5477	1037	1597	2634	2.5	70.6
14*b*	31	1¼	64.3	112	2123	3218	5341	894	1604	2498	5.5	66.0
15*a*	31	3¼	64.2	65	2109	3038	5147	880	1424	2304	3.2	69.4
15*b*	30	0¾	64.1	68	2005	3262	5267	776	1648	2424	3.5	61.5
16*a*	33	1½	64.5	101	2254	3384	5638	1025	1770	2795	4.7	66.6
16*b*	33	3¾	64.6	75	2268	3559	5827	1039	1945	2984	3.4	63.7
17*a*	34	1	64.3	111	2316	3891	6207	1087	2277	3364	5.1	59.4
17*b*	33	1½	64.4	112	2259	3858	6117	1030	2244	3274	5.2	58.5
18*a*	32	1¼	64.0	93	2163	3592	5755	934	1978	2912	4.5	60.2
18*b*	33	2¼	64.0	95	2243	3779	6022	1014	2165	3179	4.4	59.3
19	29	2¼	63.9	102	1994	3270	5264	765	1656	2421	5.4	61.0
20	..	..	..	..	..	..	..	..	..	..	..	..
21, 22	..	..	..	..	..	..	..	..	..	..	..	..

"This was my last year at Rothamsted," said I, "and I feel a peculiar interest in looking over the results after such a lapse of time. When this crop was growing, my father, a good practical farmer, but with little faith in chemical manures, paid me a visit. We went to the experimental wheat-field. The first two plots, 0 and 1, had been dressed, the one with superphosphate, the other with potash, soda, and magnesia. My father did not seem much impressed with this kind of chemical manuring. Stepping to the next plot, where 14 tons of barn-yard manure had been used, he remarked, "this is good, what have you here?"

"Never mind," said I, "we have better crops farther on."

The next plot, No. 3, was the one continuously unmanured. "I can beat this myself," said he, and passed on to the next. "This is better," said he, "what have you here?"

"Superphosphate and sulphate of ammonia."

"Well, it is a good crop, and the straw is bright and stiff."—It turned out 30 bushels per acre, 63 lbs. to the bushel.

The next six plots had received very heavy dressings of ammonia-salts, with superphosphate, potash, soda, and magnesia. He examined them with the greatest interest. "What have you here?" he asked, while he was examining *5a*, which afterwards turned out 37¼ bushels per acre.—"Potash, soda, epsom-salts, superphosphate, and ammonia—but it is the ammonia that does the good."

He passed to the next plot, and was very enthusiastic over it. "What have you here?"—"Rape-cake and ammonia," said I. —"It is a grand crop," said he, and after examining it with great interest, he passed to the next, *6a*.—"What have you here?"—"Ammonia," said I; and at *6b* he asked the same question, and I replied "ammonia." At *7a*, the same question and the same answer. Standing between *7b* and *8a*, he was of course struck with the difference in the crop; *8a* was left this year without any manure, and though it had received a liberal supply of mineral manures the year before, and minerals and ammonia-salts, and rape-cake, the year previous, it only produced this year, 3½ bushels more than the plot continuously unmanured. The contrast between the wheat on this plot and the next one, might well interest a practical farmer. There was over 15 bushels per acre more wheat on the one plot than on the other, and 1,581 lbs. more straw.

Passing to the next plot, he exclaimed "this is better, but not so good as some that we have passed."—"It has had a heavy dressing of rape-cake," said I, "equal to about 100 lbs. of ammonia per acre, and the next plot was manured this year in the same way. The only difference being that one had superphosphate and potash, soda, and magnesia, the year before, while the other had superphosphate alone." It turned out, as you see from the table, that the potash, etc., only gave half a bushel more wheat per acre the year it was used, and this year, with 2,000 lbs. of rape-cake on each plot, there is only a bushel per acre in favor of the potash, soda, and magnesia.

The next plot, 9*b*, was also unmanured and was passed by my father without comment. "Ah," said he, on coming to the two next plots, 10*a* and 10*b*, "this is better, what have you here?"—"*Nothing but ammonia*," said I, "and I wish you would tell me which is the best of the two? Last year 10*b* had a heavy dressing of minerals and superphosphate with ammonia, and 10*a* the same quantity of ammonia alone, without superphosphate or other mineral manures. And this year both plots have had a dressing of 400 lbs. each of ammonia-salts. Now, which is the best—the plot that had superphosphate and minerals last year, or the one without?"—"Well," said he, "I can't see any difference. Both are good crops."

You will see from the table, that the plot which had the superphosphate, potash, etc., the year before, gives a peck *less* wheat this year than the other plot which had none. Practically, the yield is the same. There is an increase of 13 bushels of wheat per acre—and this increase *is clearly due to the ammonia-salts alone.*

The next plot was also a splendid crop.

"What have you here?"

"Superphosphate and ammonia."

This plot (11*a*), turned out 35 bushels per acre. The next plot, with phosphates and ammonia, was nearly as good. The next plot, with potash, phosphates, and ammonia, equally good, but no better than 11*a*. There was little or no benefit from the potash, except a little more *straw*. The next plot was good and I did not wait for the question, but simply said, "ammonia," and the next "ammonia," and the next "ammonia."—Standing still and looking at the wheat, my father asked, "Joe, where can I get this ammonia?" He had previously been a little skeptical as to the value of chemistry, and had not a high opinion of "book farmers," but that wheat-crop compelled him to admit "that perhaps, after all, there might be some good in it." At any rate, he wanted to know where he could get ammonia. And, now, as then, every good farmer asks the same question: "Where can I get ammonia?" Before we attempt to answer the question, let us look at the next year's experiments.—The following is the results of the experiments the *seventh* year, 1849--50.

EXPERIMENTS AT ROTHAMSTED ON THE GROWTH OF

TABLE VII.—MANURES AND PRODUCE; 7TH SEASON, 1849–50. AFTER THE 2 TO 3 FEET DEEP. MANURES AND SEED

Plots.	Manures per Acre.									
					Superphosphate of Lime					
	Farm-yard Manure.	*Pearl-ash.*	*Soda-ash.*	*Sulphate of Magnesia.*	*Bone-ash.*	*Sulphuric Acid (Sp. gr. 1.7.)*	*Muriatic Acid.*	*Sulphate of Ammonia.*	*Muriate of Ammonia.*	*Rape-cake.*
	Tons.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
0	..	..	..	..	600	450	..	..	..	..
1	..	600	400	200	..	..	..	..	..	..
2	14	..	..	..	..	..	..	..	..	..
3	Unmanured.		..	..	..	..	..	..	..	..
4	..	..	..	..	200	..	200	300	..	..
5*a*	..	300	200	100	200	150	.	250	250	..
5*b*	..	300	200	100	200	150	..	250	250	..
6*a*	..	300	200	100	200	150	..	200	200	..
6*b*	..	00	200	100	200	150	..	200	200	..
7*a*	..	300	200	100	200	150	..	200	200	500
7*b*	..	300	200	100	200	150	..	200	200	500
8*a*	..	..	..	..	..	..	..	200	200	..
8*b*	..	..	..	..	..	..	..	200	200	..
9*a*	..	..	..	..	..	..	..	200	200	..
9*b*	..	..	..	..	..	..	..	200	200	..
10*a*	..	..	..	..	..	..	..	200	200	..
10*b*	..	300	200	100	200	150	..	..	..	..
11*a*	..	..	..	..	200	150	..	200	200	..
11*b*	..	..	..	..	200	150	..	200	200	..
12*a*	..	300	..	..	200	150	..	200	200	..
12*b*	..	300	..	..	200	150	..	200	200	..
13*a*	..	300	..	..	200	150	..	200	200	..
13*b*	..	300	..	..	200	150	..	200	200	..
14*a*	..	300	..	..	200	150	..	200	200	..
14*b*	..	300	..	..	200	150	..	200	200	..
15*a*	..	300	200	100	200	..	200	300	..	..
15*b*	..	300	200	100	200	..	200	300	..	500
16*a*	..	300	200	100	200	150	..	200	200	..
16*b*	..	300	200	100	200	150	..	200	200	..
17*a*	..	300	200	100	200	150	..	200	200	..
17*b*	..	300	200	100	200	150	..	200	200	..
18*a*	..	300	200	100	200	150	..	200	200	..
18*b*	..	300	200	100	200	150	..	200	200	..
19	..	..	..	..	200	..	200	300	..	500
20	Unmanured.		..	..	..	..		..	..	..
21, 22	Mixture of the residue of most of the other manures.								..	..

WHEAT, YEAR AFTER YEAR, ON THE SAME LAND.

HARVEST OF 1849 THE FIELD WAS TILE-DRAINED IN EVERY ALTERNATE FURROW, (RED CLUSTER), SOWN IN AUTUMN, 1849.

Plots.	Produce per Acre, etc.							Increase ℔ Acre by Manure.			Offal Corn to 100 Dressed.	Corn to 100 Straw.
	Dressed Corn.			Offal Corn.	Total Corn.	Straw and Chaff.	Total Produce (Corn and Straw.)	Corn.	Straw and Chaff.	Total Produce.		
	Quantity.		Weight per Bushel.									
	Bush.	Pks.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.		
0	19	1½	60.8	42	1220	2037	3257	218	318	536	3.5	59 9
1	..	..	..	..	..	..	..	..	..	..	..	..
2	28	2	61.9	98	1861	3245	5106	859	1526	2385	5.4	57 3
3	15	3¼	60.6	44	1002	1719	2721	..	..	..	4.5	58.2
4	27	3	61.2	87	1785	3312	5097	783	1593	2376	5.1	53.9
5*a*	29	3½	60.4	171	1974	4504	6478	972	2785	3757	9.5	43.8
5*b*	30	3	60.4	160	2018	4379	6397	1016	2660	3676	8.6	46.1
6*a*	30	0½	61.1	119	1960	3927	5887	958	2208	3166	6.3	49.9
6*b*	29	3½	61.3	148	1980	3959	5939	978	2240	3218	8.0	50.0
7*a*	32	1	61.0	167	2134	4485	6619	1132	2766	3898	8.4	47.9
7*b*	32	0¼	61.2	150	2112	4280	6392	1110	2561	3671	7.6	49.4
8*a*	28	3	61.1	101	1856	3407	5263	854	1688	2542	5.5	54.5
8*b*	30	1	61.0	103	1948	3591	5539	946	1872	2818	5.6	54.2
9*a*	30	1½	60.4	118	1951	3550	5501	949	1831	2780	6.3	55 0
9*b*	27	2¾	60.8	80	1762	3165	4927	760	1446	2206	4.7	55.7
10*a*	26	3¾	60.2	100	1721	3089	4810	719	1370	2089	6.1	55.7
10*b*	17	3¾	61.1	76	1171	1949	3120	169	230	399	6.8	60.1
11*a*	30	3¼	61.0	121	2001	3806	5807	999	2087	3086	6.4	52.6
11*b*	29	1½	61.1	145	1940	3741	5681	938	2022	2960	8.0	51.9
12*a*	29	3¾	61.5	94	1935	3921	5856	933	2202	3135	5.1	49.4
12*b*	30	3¾	61.4	115	2013	3905	5918	1011	2186	3197	5.9	51.5
13*a*	31	3¾	60.2	105	2027	4026	6053	1025	2307	3332	5.4	50.3
13*b*	30	1½	61.0	111	1964	4008	5972	962	2289	3251	6.0	49.0
14*a*	31	1¾	61.1	102	2023	4052	6075	1021	2333	3354	5.3	49.9
14*b*	31	1½	61.5	65	1995	4015	6010	993	2296	3289	3.2	49.7
15*a*	26	0¼	61.5	90	1693	3321	5014	691	1602	2293	5.7	51.0
15*b*	30	2½	61.0	59	1942	3926	5868	940	2207	3147	3.0	49.5
16*a*	33	2½	60.3	108	2134	5103	7237	1132	3384	4516	5.3	41.8
16*b*	33	3	60.4	122	2159	4615	6774	1157	2896	4053	6.0	46.8
17*a*	31	1	61.2	73	1985	4126	6111	983	2407	3390	3.8	48.1
17*b*	29	2½	61.5	139	1961	4034	5995	959	2315	3274	7.7	48.6
18*a*	29	3¼	61.2	110	1934	3927	5861	932	2208	3140	6.1	49.3
18*b*	28	2½	60.9	103	1845	3844	5689	843	2125	2968	5.7	48.0
19	29	0	60.8	88	1850	3527	5377	848	1808	2656	4.9	52.4
20	14	0	59.1	40	868	1639	2507	—134	—80	–214	4.5	53.0
21, 22	..	..	..	..	..	..	..	..	..	..	..	..

The summer of 1850 was unusually cool and unfavorable for wheat. It will be seen that on all the plots the yield of grain is considerably lower than last year, with a greater growth of straw.

You will notice that 10*b*, which last year gave, with ammonia-salts alone, 32¼ bushels, this year, with superphosphate, potash, soda, and sulphate of magnesia, gives less than 18 bushels, while the adjoining plot, dressed with ammonia, gives nearly 27 bushels. In other words, the ammonia alone gives 9 bushels per acre more than this large dressing of superphosphate, potash, etc.

On the three plots, 8*a*, 8*b* and 9*a*, a dressing of ammonia-salts alone gives in *each case*, a larger yield, both of grain and straw, than the 14 tons of barn-yard manure on plot 2. And recollect that this plot has now received 98 tons of manure in seven years.

"That," said the Doctor, "is certainly a very remarkable fact."

"It is so," said the Deacon.

"But what of it?" asked the Squire, "even the Professor, here, does not advise the use of ammonia-salts for wheat."

"That is so," said I, "but perhaps I am mistaken. Such facts as those just given, though I have been acquainted with them for many years, sometimes incline me to doubt the soundness of my conclusions. Still, on the whole, I think I am right."

"We all know," said the Deacon, "that you have great respect for your own opinions."

"Never mind all that," said the Doctor, "but tell us just what you think on this subject."

"In brief," said I, "my opinion is this. We need ammonia for wheat. But though ammonia-salts and nitrate of soda can often be used with decided profit, yet I feel sure that we can get ammonia or nitrogen at a less cost per lb. by buying bran, malt-roots, cotton-seed-cake, and other foods, and using them for the double purpose of feeding stock and making manure."

"I admit that such is the case," said the Doctor, "but here is a plot of land that has now had 14 tons of manure every year for seven years, and yet there is a plot along side, dressed with ammonia-salts furnishing less than half the ammonia contained in the 14 tons of manure, that produces a better yield of wheat."

"That," said I, "is simply because the nitrogen in the manure is not in an available condition. And the practical question is, how to make the nitrogen in our manure more immediately available. It is one of the most important questions which agricultural science is called upon to answer. Until we get more light, I feel sure in saying that one of the best methods is, to feed our animals on richer and more easily digested food."

The following table gives the results of the *eighth* season of 1850--51.

EXPERIMENTS AT ROTHAMSTED ON THE GROWTH OF

TABLE VIII.—MANURES AND PRODUCE; 8TH SEASON. 1850-51.

Plots.	MANURES PER ACRE.											
							Superphosphate of Lime.					
	Farm-yard Manure.	*Cut Wheat-straw and Chaff.*	*Common Salt.*	*Sulphate of Potass.*	*Soda-Ash.*	*Sulphate of Magnesia.*	*Bone-ash.*	*Sulphuric Acid (Sp. gr. 1.7.)*	*Muriatic Acid.*	*Sulphate of Ammonia.*	*Muriate of Ammonia.*	*Rape-Cake.*
	Tons.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
0	..	..	..	..	..	..	600	450	..	..	..	..
1	..	..	..	600	400	200	..	..	..	..	..	..
2	14	..	..	..	..	..	..	..	..	..	..	..
3	Unmanured.		..	..	..	..	..	..	..	..	..	..
4	..	..	..	..	..	..	200	..	200	400	..	..
5*a*	..	..	..	300	200	100	200	150	..	300	300	..
5*b*	..	..	..	300	200	100	200	150	..	300	300	..
6*a*	..	..	..	300	200	100	200	150	..	200	200	..
6*b*	..	..	..	300	200	100	200	150	..	200	200	..
7*a*	..	..	..	300	200	100	200	150	..	200	200	1000
7*b*	..	..	..	300	200	100	200	150	..	200	200	1000
8*a*	..	5000	..	..	..	..	..	..	..	..	..	..
8*b*	..	..	..	300	200	100	200	150	..	100	100	..
9*a*	..	..	..	..	..	..	..	..	..	200	200	..
9*b*	..	..	..	..	..	..	..	..	..	200	200	..
10*a*	..	..	..	..	..	..	..	..	..	200	200	..
10*b*	..	..	..	..	..	..	..	..	..	200	200	..
11*a*	..	..	..	..	..	..	200	150	..	200	200	..
11*b*	..	..	..	..	..	..	200	150	..	200	200	..
12*a*	..	..	..	200	100	..	200	150	..	200	200	..
12*b*	..	..	..	200	100	..	200	150	..	200	200	..
13*a*	..	..	..	300	..	..	200	150	..	200	200	..
13*b*	..	..	..	300	..	..	200	150	..	200	200	..
14*a*	..	..	..	200	..	100	200	150	..	200	200	..
14*b*	..	..	..	200	..	100	200	150	..	200	200	..
15*a*	..	..	..	200	100	100	200	..	200	400	..	..
15*b*	..	..	..	200	100	100	200	..	200	300	..	500
16*a*	..	..	336[1]	200	100	100	200	150	..	300	300	..
16*b*	..	..	..	200	100	100	200	150	..	300	300	..
17*a*	..	..	..	200	100	100	200	150	..	200	200	..
17*b*	..	..	..	200	100	100	200	150	..	200	200	..
18*a*	..	..	..	..	..	..	..	..	..	200	200	..
18*b*	..	..	..	..	..	..	..	..	..	200	200	..
19	..	..	..	..	..	..	200	..	200	300	..	500
20	Unmanured.		..	..	..	..	..	..	..	..	..	..
21			..	..	..	..	..	..	..	..	..	..
22			..	..	..	..	..	..	..	..	..	..

[1] Top-dressed in March, 1851.

Wheat, Year after Year, on the same Land.

MANURES AND SEED (RED CLUSTER), SOWN AUTUMN, 1850.

Plots.	Produce per Acre, etc.							Increase ℔ Acre by Manure.			Offal Corn to 100 Dressed.	Corn to 100 Straw.
	Dressed Corn.			Offal Corn.	Total Corn.	Straw and Chaff.	Total Produce (Corn and Straw.)	Corn.	Straw and Chaff.	Total Produce.		
	Quantity.		Weight per Bushel.									
	Bush.	P'ks.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.		
0	18	3½	61.9	125	1296	1862	3158	213	235	448	10.7	69.6
1	18	1¼	61.7	124	1251	1845	3096	168	218	386	11.0	67.8
2	29	2½	63.6	166	2049	3094	5143	966	1467	2433	8.8	66.2
3	15	3½	61.1	114	1083	1627	2710	..	..	..	11.8	66.6
4	28	0½	62.6	159	1919	2949	4868	836	1322	2158	9.0	65.1
5*a*	36	0	63.3	194	2473	4131	6604	1390	2504	3894	8.6	59.9
5*b*	37	3¾	63.3	213	2611	4294	6905	1528	2667	4195	8.9	60.8
6*a*	33	1¾	63.3	154	2271	3624	5895	1188	1997	3185	7.2	62.6
6*b*	31	0¼	62.3	189	2119	3507	5626	1036	1880	2916	9.8	60.4
7*a*	36	3½	63.0	201	2524	4587	7111	1441	2960	4401	8.7	55.0
7*b*	37	1½	63.0	178	2532	4302	6834	1449	2675	4124	7.6	58.8
8*a*	26	0¾	62.8	141	1785	2769	4554	702	1142	1844	8.6	64.5
8*b*	27	2¼	62.6	137	1863	2830	4693	780	1203	1983	7.9	65.8
9*a*	31	1½	62.4	182	2142	3252	5394	1059	1625	2684	9.3	65.9
9*b*	29	0¼	62.0	170	1970	2942	4912	887	1315	2202	9.5	67.0
10*a*	28	3½	61.9	179	1966	3070	5036	883	1443	2326	10.0	64.0
10*b*	28	2½	62.5	149	1937	3048	4985	854	1421	2275	8.3	63.5
11*a*	32	2¾	62.3	181	2216	3386	5602	1133	1759	2892	8.9	65.4
11*b*	31	2¾	62.5	181	2163	3302	5465	1080	1675	2755	9.1	65.5
12*a*	32	3	63.1	165	2234	3600	5834	1151	1973	3124	8.0	62.0
12*b*	32	2¼	62.5	166	2203	3581	5784	1120	1954	3074	8.2	61.5
13*a*	30	2¾	62.6	180	2102	3544	5646	1019	1917	2936	9.4	59.3
13*b*	30	3¼	62.3	160	2083	3440	5523	1000	1813	2813	8.3	60.5
14*a*	31	0¼	62.9	168	2120	3605	5725	1037	1978	3015	8.6	58.8
14*b*	31	0½	62.8	165	2121	3537	5658	1038	1910	2948	8.4	59.9
15*a*	27	0½	62.7	138	1839	3041	4880	756	1414	2170	8.1	60.5
15*b*	30	2½	62.9	148	2077	3432	5509	994	1805	2799	7.6	60.5
16*a*	36	3¼	63.5	161	2499	4234	6733	1416	2607	4023	6.9	59.0
16*b*	36	2¾	63.4	176	2501	4332	6833	1418	2705	4123	7.6	57.7
17*a*	31	3½	63.3	131	2149	3597	5746	1066	1970	3036	6.5	59.7
17*b*	30	2¼	63.1	152	2079	3406	5485	996	1779	2775	7.9	61.0
18*a*	30	3¼	63.0	139	2083	3390	5473	1000	1763	2763	7.2	64.1
18*b*	31	0¾	62.4	143	2090	3586	5676	1007	1959	2966	7.3	58.3
19	30	1	62.4	144	2031	3348	5379	948	1721	2669	7.7	60.7
20	14	1	60.8	89	956	1609	2565	–127	—18	–145	10.2	59.4
21 } 22 }	17	3½	61.9	127	1232	1763	2995	149	136	285	11.5	69.9

The plot continuously unmanured, gives about 16 bushels of wheat per acre.

The plot with barn-yard manure, nearly 30 bushels per acre.

400 lbs. of ammonia-salts *alone*, on plot 9*a*, 31¼ bushels; on 9*b*, 29 bushels; on 10*a* and 10*b*, nearly 29 bushels each. This is remarkable uniformity.

400 lbs. ammonia-salts and a large quantity of mineral manures in addition, on *twelve* different plots, average not quite 32 bushels per acre.

"The superphosphate and minerals," said the Deacon, "do not seem to do much good, that is a fact."

You will notice that 336 lbs. of common salt was sown on plot 16*a*. It does not seem to have done the slightest good. Where the salt was used, there is 2 lbs. less grain and 98 lbs. less straw than on the adjoining plot 16*b*, where no salt was used, but otherwise manured alike. It would seem, however, that the quality of the grain was slightly improved by the salt. The salt was sown in March as a top-dressing.

"It would have been better," said the Deacon, "to have sown it in autumn with the other manures."

"The Deacon is right," said I, "but it so happens that the next year and the year after, the salt *was* applied at the same time as the other manures. It gave an increase of 94 lbs. of grain and 61 lbs. of straw in 1851, but the following year the same quantity of salt used on the same plot did more harm than good."

Before we leave the results of this year, it should be observed that on 8*a*, 5,000 lbs. of cut straw and chaff were used per acre. I do not recollect seeing anything in regard to it. And yet the result was very remarkable—so much so indeed, that it is a matter of regret that the experiment was not repeated.

This 5,000 lbs. of straw and chaff gave an increase of more than 10 bushels per acre over the continuously unmanured plot.

"Good," said the Deacon, "I have always told you that you under-estimated the value of straw, especially in regard to its *mechanical* action."

I did not reply to this remark of the good Deacon. I have never doubted the good effects of anything that lightens up a clay soil and renders it warmer and more porous. I suppose the great benefit derived from this application of straw must be attributed to its ameliorating action on the soil. The 5,000 lbs. of straw and chaff produced a crop within nearly 3 bushels per acre of the plot manured every year with 14 tons of barn-yard manure.

"I am surprised," said the Doctor, "that salt did no good. I have seen many instances in which it has had a wonderful effect on wheat."

"Yes," said I, "and our experienced friend, John Johnston, is very decidedly of the opinion that its use is highly profitable. He sows a barrel of salt per acre broadcast on the land at the time he sows his wheat, and I have myself seen it produce a decided improvement in the crop."

We have now given the results of the first *eight* years of the experiments. From this time forward, the *same manures* were used year after year on the same plot.

The results are given in the accompanying tables for the following twelve years—harvests for 1852–53–54–55–56–57–58–59–60–61–62 and 1863. Such another set of experiments are not to be found in the world, and they deserve and will receive the careful study of every intelligent American farmer.

"I am with you there," said the Deacon. "You seem to think that I do not appreciate the labors of scientific men. I do. Such experiments as these we are examining command the respect of every intelligent farmer. I may not fully understand them, but I can see clearly enough that they are of great value."

Experiments at Rothamsted on the Growth of Wheat, Year after Year, on the same Land.

Table IX.—Manures per Acre per Annum (with the exceptions explained in the Notes on p. 203), for 12 Years in succession—namely, for the 9th, 10th, 11th, 12th, 13th, 14th, 15th, 16th, 17th, 18th, 19th, and 20th Seasons: that is, for the crops of Harvests 1852-53-54-55-56-57-58-59-60-61-62 and 1863.*

Plots.	*Manures per Acre per Annum for 12 Years, 1851-2 to 1862-3 inclusive, except in the cases explained in the Notes on p. 203.*											
	Farmyard Manure.	Common Salt.	Sulphate of Potass.[1]	Sulphate of Soda.[1]	Sulphate of Magnesia.[1]	Superphosphate of Lime. Boneash.	Superphosphate of Lime. Sulphuric Acid (Sp. gr. 1.7).	Muriatic Acid.	Sulphate of Ammonia.	Muriate of Ammonia.	Nitrate of Soda.	Rape Cake.
	Tons.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
0	..	..	..	..	..	600	450	..	..	..	..	..
1	..	..	600	400	200	..	..	..	..	..	..	..
2	14	..	..	..	..	.	..	..	..	..	..	..
3	Unmanured		..	..	..	..	..	..	..	..	..	..
4	Unmanured		..	..	..	..	..	..	..	..	..	..
5*a*	..	..	300	200	100	200	150	..	..	..	.	..
5*b*	..	..	300	200	100	200	150	..	..	..	..	..
6*a*	..	..	300	200	100	200	150	..	100	100	..	..
6*b*	..	..	300	200	100	200	150	..	100	100	..	..
7*a*	..	..	300	200	100	200	150	..	200	200	..	..
7*b*	..	..	300	200	100	200	150	..	200	200	..	..
8*a*	..	..	300	200	100	200	150	..	300	300	..	..
8*b*	..	..	300	200	100	200	150	..	300	300	.	..
9*a*[2]	..	..	300	200	100	200	150	..	..	..	550	..
9*b*[3]	..	..	..	..	..	..	..	..	..	..	550	..
10*a*	..	..	..	..	..	..	..	..	200	200	..	..
10*b*	..	..	.	..	..	..	..	..	200	200	..	..
11*a*	..	..	..	..	..	200	150	..	200	200	..	..
11*b*	..	..	..	..	..	200	150	..	200	200	..	..
12*a*	..	..	..	550	..	200	150	..	200	200	..	..
12*b*	..	..	..	550	..	200	150	..	200	200	..	..
13*a*	..	..	300	..	..	200	150	..	200	200	..	..
13*b*	..	..	300	..	..	200	150	..	200	200	..	..
14*a*	..	..	..	..	420	200	150	..	200	200	..	..
14*b*	..	..	..	..	420	200	150	..	200	200	..	..
15*a*	..	..	300	200	100	200	..	200	400	..	..	..
15*b*	..	..	300	200	100	200	..	200	300	..	..	500
16*a*	..	336[4]	300	200	100	200	150	..	400	400	..	..
16*b*	..	..	300	200	100	200	150	..	400	400	..	..
[4] 17*a*	..	..	..	..	..	..	..	..	200	200	..	..
17*b*	..	..	..	..	..	..	..	..	200	200	..	..
[5] 18*a*	..	..	300	200	100	200	150	..	..	..	..	..
18*b*	..	..	300	200	100	200	150	..	..	..	..	..
19	..	..	..	..	..	200	..	200	300	..	..	500
20	Unmanured		..	..	..	..	..	..	..	..	..	..
21	.	..	300	200	100	..	.	..	..	100	..	..
22	..	..	300	200	100	..	..	..	100	..	..	..

* For the particulars of the produce of each separate season, see Tables X.-XXI. inclusive.

NOTES TO TABLE IX. (p. 202.)

[1] For the 16*th and succeeding seasons*—the sulphate of potass was reduced from 600 to 400 lbs. per acre per annum on Plot 1, and from 300 to 200 lbs. on all the other Plots where it was used; the sulphate of soda from 400 to 200 lbs. on Plot 1, to 100 lbs. on all the Plots on which 200 lbs. had previously been applied, and from 550 to 336½ lbs. (two-thirds the amount) on Plots 12*a* and 12*b*; and the sulphate of magnesia from 420 to 280 lbs. (two-thirds the amount) on Plots 14*a* and 14*b*.

[2] *Plot* 9*a*—the sulphates of potass, soda, and magnesia, and the superphosphate of lime, were applied in the 12th and succeeding seasons, but not in the 9th, 10th, and 11th; and the amount of nitrate of soda was for the 9th season only 475 lbs. per acre, and for the 10th and 11th seasons only 275 lbs.

[3] *Plot* 9*b*—in the 9th season only 475 lbs. of nitrate of soda were applied.

[4] *Common salt*—not applied after the 10th season.

[5] *Plots* 17*a and* 17*b, and* 18*a and* 18*b*—the manures on these plots alternate: that is, Plots 17 were manured with ammonia-salts in the 9th season; with the sulphates of potass, soda, and magnesia, and superphosphate of lime, in the 10th; ammonia-salts again in the 11th; the sulphates of potass, soda, and magnesia, and superphosphate of lime, again in the 12th, and so on. Plots 18, on the other hand, had the sulphates of potass, soda, and magnesia, and superphosphate of lime, in the 9th season; ammonia-salts in the 10th, and so on, alternately.

Experiments at Rothamsted on the Growth of Wheat, Year after Year, on the same Land.

Table X.—Produce of the 9th Season, 1851–2. Seed (Red Cluster) sown November 7, 1851; Crop cut August 24, 1852.

Plots.	Produce per Acre, etc. (For the Manures see pp. 202 and 203.)				
	Dressed Corn.			Total Corn.	Total Produce (Corn and Straw.)
	Quantity.		Weight ℔ Bushel		
	Bush.	Pks.	lbs.	lbs.	lbs.
0	15	0¾	55.8	919	2625
1	13	1	56.9	825	2322
2	27	2¼	58.2	1716	5173
3	13	3¼	56.6	860	2457
4	13	1¼	57.3	870	2441
5*a*	16	3	57.5	1038	2941
5*b*	17	0¼	57.3	1065	3097
6*a*	20	3	57.6	1288	3869
6*b*	20	3½	57.5	1300	3904
7*a*	26	2½	56.0	1615	5465
7*b*	26	3¾	55.8	1643	5415
8*a*	27	3½	55.9	1699	5505
8*b*	27	0½	55.9	1651	5423
9*a*	25	2	55.6	1591	5305
9*b*	24	1¾	55.3	1509	4883
10*a*	21	3½	55 9	1320	4107
10*b*	22	0¼	57 3	1343	4162
11*a*	24	0¾	55.6	1472	4553
11*b*	22	1½	55.9	1387	4299
12*a*	24	1¾	57.4	1503	4760
12*b*	24	1¼	57.3	1492	4724
13*a*	24	0	57.5	1480	4702
13*b*	23	3¾	57.1	1476	4765
14*a*	24	1¾	56.9	1507	5054
14*b*	25	0¼	56.7	1530	5137
15*a*	23	1¼	57.4	1451	4663
15*b*	25	0½	56.8	1520	4941
16*a*	28	3½	55.0	1794	6471
16*b*	28	0	54.5	1700	6316
17*a*	25	2	56.5	1577	5311
17*b*	24	1½	56.9	1520	4986
18*a*	13	3	57.0	869	2556
18*b*	14	3¾	56.7	921	2685
19	24	3¾	56.1	1582	4979
20	14	0¾	56.6	875	2452
21	19	1¾	56.9	1177	3285
22	19	2¼	55.9	1176	3355

Table XI.—Produce of the 10th Season, 1853. Seed (Red Rostock) sown March 16; Crop cut September 10, and carted September 20, 1853.

Plots.	Produce per Acre, etc. (For the Manures see pp. 202 and 203).				
	Dressed Corn.			Total Corn.	Total Produce (Corn and Straw.)
	Quantity.		Weight ℔ Bushel.		
	Bush.	Pks.	lbs.	lbs.	lbs.
0	9	0¾	49.1	599	2406
1	6	1¾	46.1	404	2036
2	19	0½	51.1	1120	4492
3	5	3¼	45.1	359	1772
4	7	1	46.1	446	2116
5*a*	10	0	48.9	587	2538
5*b*	10	1	48 9	611	2741
6*a*	16	3¼	51.8	978	3755
6*b*	19	1	51.8	1072	3870
7*a*	23	2½	52.2	1369	5110
7*b*	23	2¼	51.1	1357	5091
8*a*	22	1¼	51.1	1346	5312
8*b*	24	2¼	51.1	1425	5352
9*a*	11	1	47.7	691	3090
9*b*	10	1¾	46.1	649	2902
10*a*	9	3¾	48.9	642	2691
10*b*	15	2	49.8	896	3578
11*a*	17	2	50.1	1015	3539
11*b*	18	2¾	51.1	1073	3780
12*a*	22	0	52.0	1283	4948
12*b*	23	3¼	51.1	1375	5079
13*a*	22	1¼	52.1	1341	5045
13*b*	23	2½	51.1	1396	5308
14*a*	21	2	51.2	1322	4793
14*b*	23	0¾	52.6	1347	5108
15*a*	19	0	51.1	1143	4504
15*b*	23	2½	51.1	1351	5107
16*a*	24	1½	52.5	1496	6400
16*b*	25	3¼	52.5	1537	6556
17*a*	8	1¾	49.8	520	2516
17*b*	8	3¾	48.9	539	2551
18*a*	17	3¼	52.9	1111	4496
18*b*	20	3	52.1	1256	5052
19	19	1¼	52.6	1160	4373
20	5	3¼	47.8	425	2084
21	12	3¾	50.4	753	2934
22	10	1	49.4	592	2452

Experiments at Rothamsted on the Growth of Wheat, Year after Year, on the same Land.

Table XII.—Produce of the 11th Season, 1853–4. Seed (Red Rostock) sown November 12, 1853; Crop cut August 21, and carted August 31, 1854.

Plots.	Produce per Acre, etc. (For the Manures see pp. 202 and 203). Dressed Corn. Quantity.		Weight ℔ Bushel.	Total Corn.	Total Produce (Corn and Straw).
	Bush.	Pks.	lbs.	lbs.	lbs.
0	26	1¾	61.0	1672	3786
1	24	1½	60.2	1529	4060
2	41	0½	62.5	2675	7125
3	21	0¼	60.6	1359	3496
4	23	3½	61.1	1521	3859
5*a*	24	1½	61.0	1578	4098
5*b*	24	0	61.6	1532	4035
6*a*	33	2¾	61 8	2186	6031
6*b*	34	2¼	61.8	2239	6294
7*a*	45	2¼	61 9	2950	8553
7*b*	45	1½	61.8	2944	8440
8*a*	47	1¾	61.4	3065	9200
8*b*	49	2½	61.8	3208	9325
9*a*	38	3	60.7	2456	6598
9*b*	38	3½	60.7	2480	6723
10*a*	34	1½	60.5	2211	5808
10*b*	39	0¾	61.6	2535	7003
11*a*	44	2	61.1	2859	8006
11*b*	43	0½	61.2	2756	7776
12*a*	45	3¼	62.2	2966	8469
12*b*	45	1½	62.2	2939	8112
13*a*	45	0½	62 2	2913	8311
13*b*	43	3½	62.2	2858	8403
14*a*	45	1¼	62.2	2946	8498
14*b*	44	0½	62.2	2863	8281
15*a*	43	1¼	62.1	2801	7699
15*b*	43	1	62.4	2810	8083
16*a*	49	2¼	61.7	3230	9932
16*b*	50	0¾	61 7	3293	9928
17*a*	45	3	62.1	2948	8218
17*b*	42	2¼	62.2	2732	7629
18*a*	24	0	61.2	1526	3944
18*b*	23	2¾	61.0	1511	3888
19	41	0¾	61.7	2666	7343
20	22	3	60.8	1445	3662
21	32	0½	61.2	2030	5470
22	31	3	61.0	1994	5334

Table XIII.—Produce of the 12th Season, 1854–5. Seed (Red Rostock) sown November 9, 1854; Crop cut August 26, and carted September 2, 1855.

Plots.	Produce per Acre, etc. (For the Manures see pp. 202 and 203). Dressed Corn. Quantity.		Weight ℔ Bushel.	Total Corn.	Total Produce (Corn and Straw).
	Bush.	Pks.	lbs.	lbs.	lbs.
0	17	0	60.7	1096	2822
1	18	2	60.5	1179	3069
2	34	2½	62.0	2237	6082
3	17	0	59.2	1072	2859
4	18	2½	59.5	1168	3000
5*a*	18	2	59.9	1157	2976
5*b*	18	0½	60.1	1143	2943
6*a*	27	3	60.3	1753	4590
6*b*	28	1	60.9	1811	4848
7*a*	32	2¾	59.4	2084	5995
7*b*	33	1¼	59.5	2138	6296
8*a*	29	3	58.8	1909	5747
8*b*	33	0¾	58.7	2153	6495
9*a*	29	2½	58.3	1932	5878
9*b*	25	1½	57.3	1605	4817
10*a*	19	3¾	57.1	1285	3797
10*b*	28	0½	58.9	1805	5073
11*a*	18	3	55.3	1210	3694
11*b*	24	2½	56.3	1580	4733
12*a*	30	0¼	59.5	1940	5478
12*b*	33	2	60.2	2172	6182
13*a*	29	0	59.9	1924	5427
13*b*	32	2	60.4	2110	5980
14*a*	29	3	60.0	1954	5531
14*b*	33	1¾	60.0	2158	5161
15*a*	31	3¼	60.0	2030	5855
15*b*	33	3	60.6	2193	6415
16*a*	33	1¼	58.2	2100	6634
16*b*	32	2	58.2	2115	7106
17*a*	18	3¾	60.8	1227	3203
17*b*	17	0½	60.3	1110	2914
18*a*	32	3¾	60 9	2127	6144
18*b*	33	1¾	60.8	2170	6385
19	30	0½	58 7	1967	5818
20	17	2½	61.1	1155	2986
21	24	1¾	60.8	1533	3952
22	24	2½	60.1	1553	4010

Experiments at Rothamsted on the Growth of Wheat, Year after Year, on the same Land.

Table XIV.—Produce of the 13th Season, 1855-6. Seed (Red Rostock) sown November 13, 1855; Crop cut August 26, and carted September 3, 1856.

Plots.	Produce per Acre, etc. (For the Manures see pp. 202 and 203.) Dressed Corn. Quantity. Bush.	Pks.	Weight ℔ Bushel. lbs.	Total Corn. lbs.	Total Produce (Corn and Straw). lbs.
0	18	1½	56.8	1179	3148
1	17	0¾	56.3	1102	3035
2	36	1¼	58.6	2277	6594
3	14	2	54.3	892	2450
4	16	1½	55.5	1026	2757
5*a*	18	3¼	56.5	1167	3179
5*b*	20	1¼	56.2	1247	3369
6*a*	27	1¼	58.2	1717	4767
6*b*	28	0½	58.5	1755	4848
7*a*	37	1	58.0	2312	6872
7*b*	36	2¼	57.6	2244	6642
8*a*	40	0½	56.8	2507	7689
8*b*	37	3¾	57.1	2400	7489
9*a*	32	1½	57.2	2019	5894
9*b*	26	0	56.3	1679	4831
10*a*	24	0¾	55 6	1505	4323
10*b*	27	2¾	57.2	1727	4895
11*a*	31	3½	57.3	2001	5518
11*b*	30	2½	57.5	1946	5389
12*a*	33	3½	58.7	2102	5949
12*b*	32	3½	58.8	2079	5804
13*a*	32	1¾	58 6	2036	5779
13*b*	30	3¼	58.9	2008	5659
14*a*	35	0¼	58.6	2195	6397
14*b*	34	0¾	59.0	2162	6279
15*a*	30	0½	59.1	1923	5444
15*b*	32	0	59.4	2045	5797
16*a*	38	0½	58.5	2426	7955
16*b*	37	3	58.7	2450	7917
17*a*	31	2½	59.0	1983	5541
17*b*	30	1½	59.1	1935	5400
18*a*	17	3½	57.8	1140	3152
18*b*	18	0	57.7	1131	3069
19	32	1	58.9	2059	5621
20	17	0¾	57.7	1075	2963
21	22	1½	58.0	1398	3927
22	21	1¾	57.8	1351	3849

Table XV.—Produce of the 14th Season, 1856-7. Seed (Red Rostock) sown November 6, 1856; Crop cut August 13, and carted August 22, 1857.

Plots.	Produce per Acre, etc. (For the Manures see pp. 202 and 203.) Dressed Corn. Quantity. Bush.	Pks.	Weight ℔ Bushel. lbs.	Total Corn. lbs.	Total Produce (Corn and Straw.) lbs.
0	18	2¼	59.0	1181	2726
1	17	2½	59.0	1118	2650
2	41	0¾	60.4	2587	5910
3	19	3¾	58.3	1236	2813
4	22	1¾	58.8	1386	2958
5*a*	22	3¾	59.0	1409	3026
5*b*	24	2¼	58.8	1512	3247
6*a*	35	1½	59 9	2211	4968
6*b*	35	1¼	59 8	2193	4950
7*a*	43	1¼	60.5	2782	6462
7*b*	46	1½	60.3	2902	6793
8*a*	47	3	60.8	3058	7355
8*b*	48	3¼	60.6	3129	7579
9*a*	43	3	60.1	2767	6634
9*b*	36	0¾	58.0	2220	5203
10*a*	29	0½	58.0	1816	4208
10*b*	34	2	58.6	2185	5060
11*a*	39	0	58.5	2432	5375
11*b*	39	0¾	58.0	2397	5317
12*a*	43	3½	60 4	2747	6394
12*b*	43	2	60.4	2729	6312
13*a*	42	3	60.6	2714	6421
13*b*	43	2	60.5	2739	6386
14*a*	43	3	60.5	2781	6439
14*b*	42	3½	60.3	2699	6351
15*a*	42	1¼	60.4	2681	6368
15*b*	44	1¾	60.0	2765	6543
16*a*	48	3¼	60.5	3131	7814
16*b*	50	0	60.5	3194	7897
17*a*	26	2¾	59.1	1642	3700
17*b*	25	3¾	58.8	1583	3523
18*a*	41	0¼	59.7	2566	6009
18*b*	40	0¼	59.8	2519	5884
19	41	2½	59.5	2600	5793
20	19	2¾	58.4	1213	2777
21	24	0	60.6	1538	3353
22	23	0½	60.6	1491	3298

Experiments at Rothamsted on the Growth of Wheat, Year after Year, on the same Land.

Table XVI.—Produce of the 15th Season, 1857-8. Seed (Red Rostock) sown November 3 and 11, 1857; Crop cut August 9, and carted August 20, 1858.

Plots.	Produce per Acre, etc. (For the Manures see pp. 202 and 203.)				
	Dressed Corn.			Total Corn.	Total Produce (Corn and Straw).
	Quantity.		Weight ℔ Bushel.		
	Bush.	Pks.	lbs.	lbs.	lbs.
0	20	3	61.2	1332	3234
1	16	1¼	60.7	1055	2685
2	38	3¼	62.6	2512	6349
3	18	0	60.4	1141	2811
4	19	0½	61.1	1206	2879
5a	18	2¾	61.5	1187	2719
5b	19	1	61.4	1227	2870
6a	28	2¼	62.1	1818	4395
6b	29	0½	62.1	1850	4563
7a	38	2¼	61.9	2450	6415
7b	39	2¼	62.3	2530	6622
8a	41	3¾	61.8	2680	7347
8b	41	3¼	61.7	2675	7342
9a	37	2¼	60.8	2384	6701
9b	23	2	58.8	1470	4158
10a	22	3½	59.6	1439	3569
10b	27	3	61.4	1775	4390
11a	30	3½	60.5	1977	4774
11b	33	0¼	60.4	2099	5117
12a	37	3¾	62.1	2437	6100
12b	37	0¾	62.1	2387	6060
13a	37	0¾	62.1	2384	6077
13b	37	0¾	62.7	2397	6074
14a	37	3¼	62.1	2413	6150
14b	38	1¼	62.0	2436	6146
15a	35	1½	62.6	2285	5800
15b	37	2	62.8	2436	6134
16a	41	3	62.1	2702	7499
16b	42	0½	62.1	2717	7530
17a	33	1¼	62.5	2150	5353
17b	33	3¼	62.5	2181	5455
18a	22	3¾	62.3	1472	3480
18b	20	2¾	62.4	1338	3305
19	33	1¼	62.5	2177	5362
20	17	0	60.3	1089	2819
21	24	1¾	61.5	1574	3947
22	22	0	61.5	1412	3592

Table XVII.—Produce of the 16th Season, 1858-9. Seed (Red Rostock) sown November 4, 1858; Crop cut August 4, and carted August 20, 1859.

Plots.	Produce per Acre, etc. (For the Manures see pp. 202 and 203.)				
	Dressed Corn.			Total Corn.	Total Produce (Corn and Straw).
	Quantity.		Weight ℔ Bushel.		
	Bush.	Pks.	lbs.	lbs.	lbs.
0	21	2¼	54.0	1254	3564
1	19	3	55.0	1189	3489
2	36	0¾	56.5	2263	7073
3	18	1¼	52.5	1051	3226
4	19	0¾	55.0	1188	3418
5a	20	2¼	56.0	1277	3600
5b	20	2½	56.0	1273	3666
6a	29	2½	56.5	1808	5555
6b	30	0½	56.5	1855	5708
7a	34	2¾	55.9	2097	6774
7b	34	2½	55.9	2089	6892
8a	34	3¼	54.0	2068	7421
8b	34	0¾	53.4	2007	7604
9a	30	0	54.5	1806	7076
9b	24	2¼	50.5	1412	5002
10a	18	3¾	51.5	1207	3937
10b	25	2	52.5	1500	4920
11a	26	3½	51.4	1628	5155
11b	27	3¼	51.3	1698	5275
12a	34	2½	54.5	2060	6610
12b	34	3½	54.8	2115	6858
13a	34	0¾	55.0	2037	6774
13b	34	3½	55.0	2087	6894
14a	34	1¾	54.5	2054	6817
14b	34	2¼	54.5	2074	6774
15a	34	0¾	55.0	2053	6826
15b	35	0¼	55.0	2095	7088
16a	34	3¾	52.6	2026	7953
16b	34	1¾	52.6	2005	7798
17a	21	1¼	55.0	1247	3730
17b	19	3	54.5	1168	3541
18a	32	3¼	55.5	1973	6506
18b	32	2	56.0	1980	6630
19	30	2	55.5	1903	5926
20	17	3¼	52.5	1039	3256
21	26	1½	54.0	1538	4723
22	24	0¾	55.0	1460	4440

Experiments at Rothamsted on the Growth of Wheat, Year after Year, on the same Land.

Table XVIII.—Produce of the 17th Season, 1859-60. Seed (Red Rostock) sown November 17, 1859; Crop cut September 17 and 19, and carted October 5, 1860.

Plots.	Produce per Acre, etc. (For the Manures see pp. 202 and 203.)				
	Dressed Corn.			Total Corn.	Total Produce (Corn and Straw).
	Quantity.		Weight ℔ Bushel.		
	Bush.	Pks.	lbs.	lbs.	lbs.
0	14	1¼	53.5	826	2271
1	12	1¾	52.8	717	2097
2	32	1¼	55.5	1864	5304
3	12	3½	52.6	738	2197
4	14	2	53.0	832	2352
5a	15	2¾	54.0	903	2483
5b	16	0½	53.1	935	2595
6a	21	0½	53 7	1210	3393
6b	22	3¼	54.2	1326	3719
7a	27	3½	54 3	1612	4615
7b	27	2¼	54.3	1597	4734
8a	30	3	52.8	1759	5639
8b	31	2¾	52.3	1787	5600
9a	32	2½	51.5	1858	6635
9b	19	2¼	48.5	1155	4285
10a	15	0½	49.5	905	3118
10b	18	2½	51.0	1060	3420
11a	22	1½	51 0	1270	3773
11b	22	1½	51.2	1307	4000
12a	28	0½	53.4	1648	4878
12b	26	2¼	53.5	1577	4664
13a	26	0¾	54.3	1575	4568
13b	27	0½	53.8	1600	4637
14a	27	1½	53.7	1583	4636
14b	27	0¼	53.2	1563	4666
15a	25	1½	53.8	1510	4387
15b	28	0	54.0	1614	4704
16a	32	2	52 0	1856	5973
16b	32	3	51.7	1889	6096
17a	24	0¼	54.1	1409	4109
17b	26	1½	54.3	1548	4518
18a	15	1¼	51.5	929	2649
18b	16	1¼	54.6	963	2706
19	24	0½	53.0	1435	4178
20	12	0¼	51.5	722	2155
21	15	2	52.5	893	2639
22	13	3¼	53.8	847	2414

Table XIX.—Produce of the 18th Season, 1860-1. Seed (Red Rostock) sown November 5, 1860; Crop cut August 20, and carted August 27, 1861.

Plots.	Produce per Acre, etc. (For the Manures see pp. 202 and 203.)				
	Dressed Corn.			Total Corn.	Total Produce (Corn and Straw).
	Quantity.		Weight ℔ Bushel.		
	Bush.	Pks.	lbs.	lbs.	lbs.
0	15	1½	57.6	1001	2769
1	12	3¾	57.6	828	2215
2	34	3½	60.5	2202	5303
3	11	1¼	57.4	736	1990
4	11	3½	58.0	863	2193
5a	15	1¾	59.1	1047	2540
5b	15	1½	59.0	1082	2692
6a	27	1¼	59.5	1755	4328
6b	27	3¼	59.4	1818	4501
7a	35	2¼	59.0	2263	5764
7b	34	1¼	59.0	2183	5738
8a	36	0	58.3	2290	6203
8b	34	0¼	58.5	2190	5985
9a	33	3	56.8	2162	6607
9b	13	3	53.9	909	3079
10a	12	3½	55.0	854	2784
10b	15	3¾	55.5	1033	3196
11a	23	1¾	55.3	1455	4032
11b	25	0¾	55.8	1578	4223
12a	32	1¼	58.1	2009	5201
12b	33	1¾	58.7	2144	5481
13a	33	1¼	59.9	2168	5486
13b	35	0	60.0	2304	5794
14a	33	0¼	59.1	2125	5502
14b	33	3¾	59.3	2173	5476
15a	34	1¼	60 0	2188	5506
15b	34	3	60 2	2249	5727
16a	36	1¾	58.0	2338	6761
16b	37	2	58.6	2432	6775
17a	19	1	59.3	1229	2982
17b	18	0¾	59.1	1166	2829
18a	32	1½	59.6	2050	5144
18b	33	1½	59.5	2122	5446
19	32	2	58.8	2107	5345
20	13	0½	57 9	872	2340
21	16	1¾	58.2	1109	2749
22	19	2¾	58.5	1306	3263

EXPERIMENTS AT ROTHAMSTED ON THE GROWTH OF WHEAT, YEAR AFTER YEAR, ON THE SAME LAND.

TABLE XX.—PRODUCE of the 19TH SEASON, 1861–2. SEED (Red Rostock) sown October 25, 1861; Crop cut August 29, and carted September 12, 1862.

Plots.	Produce per Acre, etc. (For the Manures see pp. 202 and 203.) Dressed Corn. Quantity.		Weight ℔ Bushel.	Total Corn.	Total Produce (Corn and Straw).
	Bush.	Pks.	lbs.	lbs.	lbs.
0	19	3½	58.5	1228	3258
1	16	2¾	58.0	1024	2772
2	38	1½	61.0	2447	6642
3	16	0	57.8	996	2709
4	16	2½	58.5	1049	2711
5*a*	17	3¾	59.0	1119	2959
5*b*	17	2½	59.0	1101	2961
6*a*	27	2	59.5	1715	4554
6*b*	28	3¼	59.8	1797	4897
7*a*	35	2¼	59.3	2200	6106
7*b*	36	0¾	59.5	2265	6178
8*a*	39	3	59.2	2477	7200
8*b*	39	0½	59.0	2452	7087
9*a*	43	1¾	59.5	2688	8738
9*b*	25	3½	56.3	1641	4897
10*a*	23	0¼	56.5	1457	4050
10*b*	24	3¼	57.5	1600	4443
11*a*	26	2¾	58.0	1706	4548
11*b*	27	0¼	58.0	1734	4607
12*a*	34	1¼	58.0	2096	5745
12*b*	33	0¾	58.0	2025	5634
13*a*	31	3¾	58.0	1953	5542
13*b*	32	2¾	58.0	2019	5691
14*a*	30	1¾	58.0	1886	5283
14*b*	32	0¼	58.1	2008	5558
15*a*	30	1¾	58.3	1872	5268
15*b*	32	2¾	58.3	2029	5787
16*a*	36	1¼	58.0	2225	6752
16*b*	36	0½	57.5	2233	6730
17*a*	27	3½	58.1	1747	4827
17*b*	27	2¼	58.1	1685	4762
18*a*	18	1½	58.5	1168	3161
18*b*	18	2¾	58 5	1195	3335
19	23	1½	57.2	1479	4132
20	12	1½	57.3	818	2335
21	20	1½	58.1	1273	3465
22	20	0¼	58.0	1250	3430

TABLE XXI.—PRODUCE of the 20TH SEASON, 1862–3. SEED (Red Rostock) sown November 17, 1862; Crop cut August 10, and carted August 18, 1863.

Plots.	Produce per Acre, etc. (For the Manures see pp. 202 and 203.) Dressed Corn. Quantity.		Weight ℔ Bushel.	Total Corn.	Total Produce (Corn and Straw).
	Bush.	Pks.	lbs.	lbs.	lbs.
0	22	0½	62.6	1429	3,254
1	20	3	62.8	1334	3.079
2	44	0	63.1	2886	7,165
3	17	1	62.7	1127	2,727
4	20	1	62.3	1303	2,957
5*a*	19	2½	63.0	1283	2,970
5*b*	19	3	63.0	1296	3,064
6*a*	39	1½	62.3	2522	6,236
6*b*	39	3	62.3	2534	6,250
7*a*	53	1¼	62.6	3477	9,330
7*b*	54	0	62.5	3507	9,385
8*a*	56	2¼	62.3	3668	10,383
8*b*	54	3¼	62.3	3559	10,048
9*a*	55	2¼	62.1	3576	9,888
9*b*	41	1¾	62.5	2723	6,920
10*a*	39	0½	62.6	2587	6,068
10*b*	43	2¼	62.8	2858	6.914
11*a*	45	0	62.5	2979	7,212
11*b*	46	2	62.1	3060	7,519
12*a*	54	2¾	62.1	3533	8,976
12*b*	53	1	62.2	3454	8,819
13*a*	53	1	62.6	3453	9,192
13*b*	53	1¼	62.5	3439	9,238
14*a*	54	1¾	62.5	3527	8,986
14*b*	53	1¾	62.5	3450	8,749
15*a*	48	1¼	62.5	3114	8,276
15*b*	48	0	62.9	3127	8,240
16*a*	56	2¾	62.4	3710	10,717
16*b*	55	0¼	62.3	3607	10,332
17*a*	21	0½	62.8	1370	3,288
17*b*	21	1½	62.8	1389	3,292
18*a*	46	1½	62.6	3006	7,889
18*b*	46	0¾	62.8	3009	7,737
19	46	2¾	62.9	3054	7,577
20	17	2¾	62.5	1137	2,609
21	27	2½	62 5	1796	4,279
22	29	3	62.4	1907	4,599

The *ninth* season (1851-2), was unusually cold in June and wet in August. It will be seen that the wheat, both in quantity and quality, is the poorest since the commencement of the experiments. The unmanured plot gave less than 14 bushels of dressed grain per acre; the plot with barn-yard manure, less than 28 bushels, and the best yield in the whole series was not quite 29 bushels per acre, and only weighed 55 lbs. per bushel. On the same plot, the year before, with precisely the same manure, the yield was nearly 37 bushels per acre, and the weight per bushel, 63½ lbs. So much for a favorable and an unfavorable season.

The *tenth* season (1852–3), was still more unfavorable. The autumn of 1852 was so wet that it was impossible to work the land and sow the wheat until the 16th of March 1853.

You will see that the produce on the unmanured plot was less than 6 bushels per acre. With barn-yard manure, 19 bushels, and with a heavy dressing of ammonia-salts and minerals, not quite 26 bushels per acre. With a heavy dressing of superphosphate, not quite 9¼ bushels per acre, and with a full dressing of mixed mineral manures and superphosphate, 10 bushels per acre.

The weight per bushel on the unmanured plot was 45 lbs.; with mixed mineral manures, 48½ lbs.; with ammonia-salts alone, 48½ lbs.; with barn-yard manure, 51 lbs.; and with ammonia-salts and mixed mineral manures, 52¼ lbs.

Farmers are greatly dependent on the season, but the good farmer, who keeps up the fertility of his land stands a better chance of making money (or of losing less), than the farmer who depends on the unaided products of the soil. The one gets 6 bushels per acre, and 1,413 lbs. of straw of very inferior quality; the other gets 20 to 26 bushels per acre, and 5,000 lbs. of straw. And you must recollect that in an unfavorable season we are pretty certain to get high prices.

The *eleventh* season (1853-4,) gives us much more attractive-looking figures! We have over 21 bushels per acre on the plot which has grown eleven crops of wheat in eleven years without any manure.

With barn-yard manure, over 41 bushels per acre. With ammonia-salts alone (17*a*), 45¾ bushels. With ammonia-salts and mixed minerals, (16*b*), over 50 bushels per acre, and 6,635 lbs. of straw. A total produce of nearly 5½ tons per acre.

The *twelfth* season (1854–5), gives us 17 bushels of wheat per acre on the continuously unmanured plot. Over 34½ bushels on the plot manured with barn-yard manure. And I think, for the first time since the commencement of the experiments, this plot produces the largest yield of any plot in the field. And well it may, for it has now had, in twelve years, 168 tons of barn-yard manure per acre!

Several of the plots with ammonia-salts and mixed minerals, are nearly up to it in grain, and ahead of it in straw.

The *thirteenth* season (1855–6), gives 14½ bushels on the unmanured plot; over 36¼ bushels on the plot manured with barn-yard manure; and over 40 bushels on 8*a*, dressed with 600 lbs. ammonia-salts and mixed mineral manures. It will be noticed that 800 lbs. ammonia-salts does not give quite as large a yield this year as 600 lbs. I suppose 40 bushels per acre was all that the *season* was capable of producing, and an extra quantity of ammonia did no good. 400 lbs. of ammonia-salts, on 7*a*, produced 37¼ bushels per acre, and 800 lbs. on 16*b*, only 37¾ bushels. That extra half bushel of wheat was produced at considerable cost.

The *fourteenth* season (1856–7), gives 20 bushels per acre on the unmanured plot, and 41 bushels on the plot with barn-yard manure. Mixed mineral manures alone on 5*a* gives nearly 23 bushels per acre. Mixed mineral manures and 200 lbs. ammonia-salts, on 6*a*, give 35¼ bushels. In other words the ammonia gives us over 12 extra bushels of wheat, and 1,140 lbs. of straw. Mineral manures and 400 lbs. ammonia-salts, on 7*b*, give 46¼ bushels per acre. Mineral manures and 600 lbs. ammonia-salts, on 8*b*, give nearly 49 bushels per acre. Mineral manures and 800 lbs. of ammonia-salts, on 16*b*, give 50 bushels per acre, and 4,703 lbs. of straw.

"This exceedingly heavy manuring," said the Deacon, "does not pay. For instance,

"200	lbs.	ammonia-salts	give an increase	of 12¼	bushels	per acre.
400	"	"	"	" 23¼	"	"
600	"	"	"	" 26	"	"
800	"	"	"	" 27	"	"

The Deacon is right, and Mr. Lawes and Dr. Gilbert call especial attention to this point. The 200 lbs. of ammonia-salts contain about 50 lbs. of ammonia, and the 400 lbs., 100 lbs. of ammonia. And as I have said, 100 lbs. of ammonia per acre is an unusually heavy dressing. It is as much ammonia as is contained in 1,000 lbs. of average Peruvian guano. We will recur to this subject.

The *fifteenth* season (1857–8,) gives a yield of 18 bushels of wheat per acre on the continuously unmanured plot, and nearly 39 bushels on the plot continuously manured with 14 tons of barn-yard manure. Mixed mineral manures on 5*a* and 5*b*, give a mean yield of less than 19 bushels per acre.

Mixed mineral manures and 100 lbs. ammonia-salts, on plots 21 and 22, give 23¼ bushels per acre. In other words:

25 lbs. ammonia	(100 lbs. ammonia-salts),	gives an *increase* of	4½	bush.
50 " "	(200 " " "),	" " " "	10	"
100 " "	(400 " " "),	" " " "	20	"
150 " "	(600 " " "),	" " " "	23	"
200 " "	(800 " " "),	" " " "	23	"

"It takes," said the Deacon, "about 5 lbs. of ammonia to produce a bushel of wheat. And according to this, 500 lbs. of Peruvian guano, guaranteed to contain 10 per cent of ammonia, would give an increase of 10 bushels of wheat."

"This is a very interesting matter," said I, "but we will not discuss it at present. Let us continue the examination of the subject. I do not propose to make many remarks on the tables. You must study them for yourself. I have spent hours and days and weeks making and pondering over these tables. The more you study them the more interesting and instructive they become."

The *sixteenth* season (1858–9), gives us a little over 18¼ bushels on the unmanured plot. On the plot manured with 14 tons farm-yard manure, 36¼ bushels; and this is the highest yield this season in the wheat-field. Mixed mineral manures alone, (mean of plot 5*a* and 5*b*), give 20½ bushels.

25 lbs. ammonia (100 lbs. ammonia-salts), and mixed minerals, give 25¼ bushels, or an *increase* over minerals alone of 4¾ bushels.

50 lbs. ammonia,	an increase of	9½	bushels.
100 " "	" " "	14	"
150 " "	" " "	14	"
200 " "	" " "	14¼	"

The season was an unfavorable one for excessive manuring. It was too wet and the crops of wheat when highly manured were much laid. The quality of the grain was inferior, as will be seen from the light weight per bushel.

The *seventeenth* season (1859--60,) gives less than 13 bushels per acre on the unmanured plot; and 32¼ bushels on the plot manured with 14 tons farm-yard manure. This season (1860), was a miserable year for wheat in England. It was both cold and wet. Mixed mineral manures, on plots 5*a* and 5*b*, gave nearly 16 bushels per acre. 25 lbs. ammonia, in addition to the above, gave less than 15 bushels. In other words it gave no *increase* at all.

50 lbs. ammonia,	gave an *increase* of	6	bushels.
100 " "	" " " "	11¾	"
150 " "	" " " "	15½	"
200 " "	" " " "	16¾	"

It was a poor year for the wheat-grower, and that, whether he manured excessively, liberally, moderately, or not at all.

"I do not quite see that," said the Deacon, "the farm-yard manure gave an *increase* of nearly 20 bushels per acre. And the quality of the grain must have been much better, as it weighed 3½ lbs. per bushel more than the plot unmanured. If the wheat doubled in price, as it ought to do in such a poor year, I do not see but that the good farmer who had in previous years made his land rich, would come out ahead."

"Good for the Deacon," said I. "'Is Saul also among the prophets?'" If the Deacon continues to study these experiments much longer, we shall have him advocating chemical manures and high farming!

The *eighteenth* season (1860--1,) gave less than 11½ bushels per acre on the unmanured plot; and nearly 35 bushels on the manured plot.

The mixed mineral manures, gave nearly		..........15½	bushels.
" " "	and 25 lbs. ammonia	..18¼	"
" " "	" 50 " "	27¾	"
" " "	" 100 " "	35	"
" " "	" 150 " "	35	"
" " "	" 200 " "	37	"

The *nineteenth* season (1861–2,) gave 16 bushels per acre on the unmanured plot, and over 38¼ bushels on the plot manured with farm-yard manure.

Mixed mineral manures, gave nearly		18	bushels	per acre.
" " "	and 25 lbs. ammonia	..20¼	"	"
" " "	" 50 " "	28¼	"	"
" " "	" 100 " "	36	"	"
" " "	" 150 " "	39½	"	"
" " "	" 200 " "	36¼	"	"

The *twentieth* season (1862–3), gave 17¼ bushels on the unmanured plot, and 44 bushels per acre on the manured plot.

Mixed mineral manures alone gave		...........19¾	bushels	per acre.
" " "	and 25 lbs. ammonia	..28¾	"	"
" " "	" 50 " "	39¾	"	"
" " "	" 100 " "	53¾	"	"
" " "	" 150 " "	55¾	"	"
" " "	" 200 " "	56	"	"

When we consider that this is the twentieth wheat-crop in succession on the same land, these figures are certainly remarkable.

"They are so," said the Deacon, "and what to me is the most surprising thing about the whole matter is, that the plot which has had no manure of any kind for 25 years, and has grown 20 wheat-crops in 20 successive years, should still produce a crop of wheat of 17¼ bushels per acre. Many of our farmers do not average 10 bushels per acre. Mr. Lawes must either have very good land, or else the climate of England is better adapted for wheat-growing than Western New York."

"I do not think," said I, "that Mr. Lawes' land is any better than yours or mine; and I do not think the climate of England is any more favorable for growing wheat without manure than our climate. If there is any difference it is in our favor."

"Why, then," asked the Doctor, "do we not grow as much wheat per acre as Mr. Lawes gets from his continuously unmanured plot?"

This is a question not difficult to answer.

1st. *We grow too many weeds.* Mr. Lawes plowed the land twice every year; and the crop was hoed once or twice in the spring to kill the weeds.

2d. We do not half work our heavy land. We do not plow it enough—do not cultivate, harrow, and roll enough. I have put wheat in on my own farm, and have seen others do the same thing, when the drill on the clay-spots could not deposit the seed an inch deep. There is "plant-food" enough in these "clay-spots" to give 17 bushels of wheat per acre—or perhaps 40 bushels—but we shall not get ten bushels. The wheat will not come up until late in the autumn—the plants will be weak and thin on the ground; and if they escape the winter they will not get a fair hold of the ground until April or May. You know the result. The straw is full of sap, and is almost sure to rust; the grain shrinks up, and we harvest the crop, not because it is worth the labor, but because we cannot cut the wheat with a machine on the better parts of the field without cutting these poor spots also. An acre or two of poor spots pull down the average yield of the field below the average of Mr. Lawes' well-worked but unmanured land.

3d. Much of our wheat is seriously injured by stagnant water *in the soil*, and standing water on the surface. I think we may safely say that one-third the wheat-crop of this county (Monroe Co., N. Y.), is lost for want of better tillage and better draining—and yet we think we have as good wheat-land and are as good farmers as can be found in this country or any other!

Unless we drain land, where drainage is needed, and unless we work land thoroughly that needs working, and unless we kill the weeds or check their excessive growth, it is poor economy to sow expensive manures on our wheat-crops.

But I do not think there is much danger of our falling into this error. The farmers who try artificial manures are the men who usually take the greatest pains to make the best and most manure from the animals kept on the farm. They know what manures cost and what they are worth. As a rule, too, such men are good farmers, and endeavor to work their land thoroughly and keep it clean. When this is the case, there can be little doubt that we can often use artificial manures to great advantage.

"You say," said the Deacon, who had been looking over the tables while I was talking, "that mixed mineral manures and 50 lbs. of ammonia give 39¾ bushels per acre. Now these mixed mineral manures contain potash, soda, magnesia, and superphosphate. And I see where superphosphate was used without any potash, soda, and magnesia, but with the same amount of ammonia, the yield is nearly 46 bushels per acre. This does not say much in favor of potash, soda, and magnesia, as manures, for wheat. Again, I see, on plot 10*b*, 50 lbs. of ammonia, *alone*, gives over 43½ bushels per acre. On plot 11*b*, 50 lbs. ammonia *and* superphosphate, give 46½ bushels. Like your father, I am inclined to ask, '*Where can I get this ammonia?*'"

CHAPTER XXVIII.

LIME AS A MANURE.

These careful, systematic, and long-continued experiments of Lawes and Gilbert seem to prove that if you have a piece of land well prepared for wheat, which will produce, without manure, say 15 bushels per acre, there is no way of making that land produce 30 bushels of wheat per acre, without directly or indirectly furnishing the soil with a liberal supply of available nitrogen or ammonia.

"What do you mean by directly or indirectly?" asked the Deacon.

"What I had in my mind," said I, "was the fact that I have seen a good dressing of lime double the yield of wheat. In such a case I suppose the lime decomposes the organic matter in the soil, or in some other way sets free the nitrogen or ammonia already in the soil; or the lime forms compounds in the soil which attract ammonia from the atmosphere. Be this as it may, the facts brought out by Mr. Lawes' experiments warrant us in concluding that the increased growth of wheat was connected in some way with an increased supply of available nitrogen or ammonia.

My father used great quantities of lime as manure. He drew it a distance of 13 miles, and usually applied it on land intended for wheat, spreading it broad-cast, after the land had received its last plowing, and harrowing it in, a few days or weeks before sowing the wheat. He rarely applied less than 100 bushels of stone-lime to the acre—generally 150 bushels. He used to say that a small dose of lime did little or no good. He wanted to use enough to change the general character of the land—to make the light land firmer and the heavy land lighter.

While I was with Mr. Lawes and Dr. Gilbert at Rothamsted, I went home on a visit. My father had a four-horse team drawing lime every day, and putting it in large heaps in the field to slake, before spreading it on the land for wheat.

"I do not believe it pays you to draw so much lime," said I, with the confidence which a young man who has learned a little of agricultural chemistry, is apt to feel in his newly acquired knowledge.

"Perhaps not," said my father, "but we have got to do something for the land, or the crops will be poor, and poor crops do not pay these times. What would you use instead of lime?"—"Lime is not a manure, strictly speaking," said I; "a bushel to the acre would furnish all the lime the crops require, even if there was not an abundant supply already in the soil. If you mix lime with guano, it sets free the ammonia; and when you mix lime with the soil it probably decomposes some compounds containing ammonia or the elements of ammonia, and thus furnishes a supply of ammonia for the plants. I think it would be cheaper to buy ammonia in the shape of Peruvian guano."

After dinner, my father asked me to take a walk over the farm. We came to a field of barley. Standing at one end of the field, about the middle, he asked me if I could see any difference in the crop. "Oh, yes," I replied, "the barley on the right-hand is far better than on the left hand. The straw is stiffer and brighter, and the heads larger and heavier. I should think the right half of the field will be ten bushels per acre better than the other."

"So I think," he said, "and now can you tell me why?"—"Probably you manured one half the field for turnips, and not the other half."—"No."—"You may have drawn off the turnips from half the field, and fed them off by sheep on the other half."—"No, both sides were treated precisely alike."—I gave it up—"Well," said he, "this half the field on the right-hand was limed, thirty years ago, and that is the only reason I know for the difference. And now you need not tell me that lime does not pay."

I can well understand how this might happen. The system of rotation adopted was, 1st clover, 2d wheat, 3d turnips, 4th barley, seeded with clover.

Now, you put on, say 150 bushels of lime for wheat. After the wheat the land is manured and sown with turnips. The turnips are eaten off on the land by sheep; and it is reasonable to suppose that on the half of the field dressed with lime there would be a much heavier crop of turnips. These turnips being eaten off by the sheep would furnish more manure for this half than the other half. Then again, when the land was in grass or clover, the limed half would afford more and sweeter grass and clover than the other half, and the sheep would remain on it longer. They would eat it close into the ground, going only on to the other half when they could not get enough to eat on the limed half. More of their droppings would be left on the limed half of the field. The lime, too, would continue to act for several years; but even after all direct benefit from the lime had ceased, it is easy to understand why the crops might be better for a long period of time.

"Do you think lime would do any good," asked the Deacon, "on our limestone land?"—I certainly do. So far as I have seen, it does just as much good here in Western New York, as it did on my father's farm. I should use it very freely if we could get it cheap enough—but we are charged from 25 to 30 cts. a bushel for it, and I do not think at these rates it will pay to use it. Even gold may be bought to dear.

"You should burn your own lime," said the Deacon, "you have plenty of limestone on the farm, and could use up your down wood."—I believe it would pay me to do so, but one man cannot do everything. I think if farmers would use more lime for manure we should get it cheaper. The demand would increase with competition, and we should soon get it at its real value. At 10 to 15 cents a bushel, I feel sure that we could use lime as a manure with very great benefit.

"I was much interested some years ago," said the Doctor, "in the results of Prof. Way's investigations in regard to the absorptive powers of soils."

His experiments, since repeated and confirmed by other chemists, formed a new epoch in agricultural chemistry. They afforded some new suggestions in regard to how lime may benefit land.

Prof. Way found that ordinary soils possessed the power of separating, from solution in water, the different earthy and alkaline substances presented to them in manure; thus, when solutions of salts of ammonia, of potash, magnesia, etc., were made to filter slowly through a bed of dry soil, five or six inches deep, arranged in a flower-pot, or other suitable vessel, it was observed that the liquid which ran through, no longer contained any of the ammonia or other salt employed. The soil had, in some form or other, retained the alkaline substance, while the water in which it was previously dissolved passed through.

Further, this power of the soil was found not to extend to the whole salt of ammonia or potash, but only to the alkali itself. If, for instance, sulphate of ammonia were the compound used in the experiments, the ammonia would be removed from solution, but the filtered liquid would contain sulphuric acid in abundance—not in the free or uncombined form, but united to lime; instead of sulphate of ammonia we should find sulphate of lime in the solution; and this result was obtained, whatever the acid of the salt experimented upon might be.

It was found, moreover, that the process of filtration was by no means necessary; by the mere mixing of an akaline solution with a proper quantity of soil, as by shaking them together in a bottle, and allowing the soil to subside, the same result was obtained. The action, therefore, was in no way referable to any physical law brought into operation by the process of filtration.

It was also found that the combination between the soil and the alkaline substance was rapid, if not instantaneous, partaking of the nature of the ordinary union between an acid and an alkali.

In the course of these experiments, several different soils were operated upon, and it was found that all soils capable of profitable cultivation possessed this property in a greater or less degeee.

Pure sand, it was found, did not possess this property. The organic matter of the soil, it was proved, had nothing to do with it. The addition of carbonate of lime to a soil did not increase its absorptive power, and indeed it was found that a soil in which carbonate of lime did not exist, possessed in a high degree the power of removing ammonia or potash from solution.

To what, then, is the power of soils to arrest ammonia, potash, magnesia, phosphoric acid, etc., owing? The above experiments lead to the conclusion that it is due to the *clay* which they contain. In the language of Prof. Way, however,

"It still remained to be considered, whether the whole clay took any active part in these changes, or whether there existed in clay some chemical compound in small quantity to which the action was due. This question was to be decided by the extent to which clay was able to unite with ammonia, or other alkaline bases; and it soon became evident that the idea of the clay as a whole, being the cause of the absorptive property, was inconsistent with all the ascertained laws of chemical combination."

After a series of experiments, Prof. Way came to the conclusion that there is in clays a peculiar class of double silicates to which the absorptive properties of soil are due. He found that the double silicate of alumina and lime, or soda, whether found naturally in soils or produced artificially, would be decomposed when a salt of ammonia, or potash, etc., was mixed with it, the ammonia, or potash, taking the place of the lime or soda.

Prof. Way's discovery, then, is not that soils have "absorptive properties"—that has been long known—but that they absorb ammonia, potash, phosphoric acid, etc., by virtue of the double silicate of alumina and soda, or lime, etc., which they contain.

Soils are also found to have the power of absorbing ammonia, or rather *carbonate* of ammonia, from the air.

"It has long been known," says Prof. Way, "that soils acquire fertility by exposure to the influence of the atmosphere—hence one of the uses of fallows. * * I find that clay is so greedy of ammonia, that if air, charged with carbonate of ammonia, so as to be highly pungent, is passed through a tube filled with small fragments of dry clay, *every particle of the gas is arrested.*"

This power of the soil to absorb ammonia, is also due to the double silicates. But there is this remarkable difference, that while either the lime, soda, or potash silicate is capable of removing the ammonia from *solution*, the *lime* silicate alone *has the power of absorbing it from the air.*

This is an important fact. Lime may act beneficially on many or most soils by converting the soda silicate into a lime silicate, or, in other words, converting a salt that will not absorb carbonate of ammonia from the air, into a salt that has this important property.

There is no manure that has been so extensively used, and with such general success as lime, and yet, "who among us," remarks Prof. Way, "can say that he perfectly understands the mode in which lime acts?" We are told that lime sweetens the soil, by neutralizing any acid character that it may possess; that it assists the decomposition of inert organic matters, and therefore increases the supply of vegetable food to plants: that it decomposes the remains of ancient rocks containing potash, soda, magnesia, etc., occurring in most soils, and that at the same time it liberates silica from these rocks; and lastly, that lime is one of the substances found uniformly and in considerable quantity in the ashes of plants, that therefore its application may be beneficial simply as furnishing a material indispensable to the substance of a plant.

These explanations are no doubt good as far as they go, but experience furnishes many facts which cannot be explained by any one, or all, of these suppositions. Lime, we all know, does much good on soils abounding in organic matter, and so it frequently does on soils almost destitute of it. It may liberate potash, soda, silica, etc., from clay soils, but the application of potash, soda, and silica has little beneficial effect on the soil, and therefore we cannot account for the action of lime on the supposition that it renders the potash, soda, etc., of the soil available to plants. Furthermore, lime effects great good on soils abounding in salts of lime, and therefore it cannot be that it operates as a source of lime for the structure of the plant.

None of the existing theories, therefore, satisfactorily account for the action of lime. Prof. Way's views are most consistent with the facts of practical experience; but they are confessedly hypothetical; and his more recent investigations do not confirm the idea that lime acts beneficially by converting the soda silicate into the lime silicate.

Thus, six soils were treated with lime water until they had absorbed from one and a half to two per cent of their weight of lime. This, supposing the soil to be six inches deep, would be at the rate of about 300 bushels of lime per acre. The amount of ammonia in the soil was determined before liming, after liming, and then after being exposed to the fumes of carbonate ammonia until it had absorbed as much as it would. The following table exhibits the results:

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
Ammonia in 1,000 grains of natural soil	0.293	0.181	0.085	0.109	0.127	0.083
Ammonia in 1,000 grains of soil after liming	0.169	0.102	0.040	0.050	.....	0.051
Ammonia in 1,000 grains of soil after liming and exposure to the vapor of ammonia	2.226	2.066	3.297	1.076	3.265	1.827
Ammonia in 1,000 grains of soil after exposure to ammonia without liming	1.906	2.557	3.286	1.097	2.615	2.028

No. 1. Surface soil of London clay.
No. 2. Same soil from 1½ to 2 feet below the surface.
No. 3. Same soil 3½ feet below the surface.
No. 4. Loam of tertiary drift 4 feet below the surface.
No. 5. Gault clay—surface soil.
No. 6. Gault clay 4 feet below the surface.

It is evident that lime neither assisted nor interfered with the absorption of ammonia, and hence the beneficial effect of liming on such soils must be accounted for on some other supposition. This negative result, however, does not disprove the truth of Prof. Way's hypothesis, for it may be that the silicate salt in the natural soils was that of lime and not that of soda. Indeed, the extent to which the natural soils absorbed ammonia—equal, in No. 3, to about 7,000 lbs. of ammonia per acre, equivalent to the quantity contained in 700 tons of barn-yard manure—shows this to have been the case.

The lime liberated one-half the ammonia contained in the soil.

"This result," says Prof. Way, "is so nearly the same in all cases, that we are justified in believing it to be due to some special cause, and probably it arises from the existence of some compound silicates containing ammonia, of which lime under the circumstances can replace one-half—forming, for instance, a double silicate of alumina, with half lime and half ammonia—such compounds are not unusual or new to the chemist."

This loss of ammonia from a heavy dressing of lime is very great. A soil five inches deep, weighs, in round numbers, 500 tons, or 1,000,000 lbs. The soil, No. 1, contained .0293 per cent of ammonia, or in an acre, five inches deep, 293 lbs. After liming, it contained .0169 per cent, or in an acre, five inches deep, 169 lbs. The loss by liming is 124 lbs. of ammonia per acre. This is equal to the quantity contained in 1200 lbs. of good Peruvian guano, or 12½ tons of barn-yard manure.

In commenting on this great loss of ammonia from liming, Prof. Way observes:

"Is it not possible, that for the profitable agricultural use, the ammonia of the soil is too tightly locked up in it? Can we suppose that the very powers of the soil to unite with and preserve the elements of manure are, however excellent a provision of nature, yet in some degree opposed to the growth of the abnormal crops which it is the business of the farmer to cultivate? There is no absolute reason why such should not be the case. A provision of nature must relate to natural circumstances; for instance, compounds of ammonia may be found in the soil, capable of giving out to the agencies of water and air quite enough of ammonia for the growth of ordinary plants and the preservation of their species; but this supply may be totally inadequate to the necessities of man. * * * Now it is not impossible that the laws which preserve the supply of vegetable nutrition in the soil, are too stringent for the requirements of an unusual and excessive vegetation, such as the cultivator must promote.

"In the case of ammonia locked up in the soil, lime may be the remedy at the command of the farmer—his means of rendering immediately available stores of wealth, which can otherwise only slowly be brought into use.

"In this view, lime would well deserve the somewhat vague name that has been given it, namely, that of a 'stimulant'; for its application would be in some sort an application of ammonia, while its excessive application, by driving off ammonia, would lead to all the disastrous effects which are so justly attributed to it.

"I do not wish to push this assumption too far," says Prof. Way, in conclusion, "but if there be any truth in it, it points out the importance of employing lime in small quantities at short intervals, rather than in large doses once in many years."

"The Squire, last year," said the Deacon, "drew several hundred bushels of refuse lime from the kiln, and mixed it with his manure. It made a powerful smell, and not an agreeable one, to the passers by. He put the mixture on a twenty-acre field of wheat, and he said he was going to beat you."

"Yes," said I, "so I understood—but he did not do it. If he had applied the lime and the manure separately, he would have stood a better chance; still, there are two sides to the question. I should not think of mixing lime with good, rich farm-yard manure; but with long, coarse, strawy manure, there would be less injury, and possibly some advantage."

"The Squire," said the Deacon, "got one advantage. He had not much trouble in drawing the manure about the land. There was not much of it left."

Lime does not always decompose organic matter. In certain conditions, it will *preserve* vegetable substances. We do not want to mix lime with manure in order to preserve it; and if our object is to increase fermentation, we must be careful to mix sufficient soil with the manure to keep it moist enough to retain the liberated ammonia.

Many farmers who use lime for the first time on wheat, are apt to feel a little discouraged in the spring. I have frequently seen limed wheat in the spring look worse than where no lime was used. But wait a little, and you will see a change for the better, and at harvest, the lime will generally give a good account of itself.

There is one thing about lime which, if generally true, is an important matter to our wheat-growers. Lime is believed to hasten the maturity of the crop. "It is true of nearly all our cultivated crops," says the late Professor Johnston, "but especially of those of wheat, that their full growth is attained more speedily when the land is limed, and that they are ready for the harvest from ten to fourteen days earlier. This is the case even with buckwheat, which becomes sooner ripe, though it yields no larger a return when lime is applied to the land on which it is grown."

In districts where the midge affects the wheat, it is exceedingly important to get a variety of wheat that ripens early; and if lime will favor early maturity, without checking the growth, it will be of great value.

A correspondent in Delaware writes: "I have used lime as a manure in various ways. For low land, the best way is, to sow it broadcast while the vegetation is in a green state, at the rate of 40 or 50 bushels to the acre; but if I can not use it before the frost kills the vegetation, I wait until the land is plowed in the spring, when I spread it on the plowed ground in about the same quantity as before. Last year, I tried it both ways, and the result was, my crop was increased at least fourfold in each instance, but that used on the vegetation was best. The soil is a low, black sand."

A farmer writes from New Jersey, that he has used over 6,000 bushels of lime on his farm, and also considerable guano and phosphates, but considers that the lime has paid the best. His farm has more than doubled in real value, and he attributes this principally to the use of lime.

"We lime," he says, "whenever it is convenient, but prefer to put it on at least one year before plowing the land. We spread from 25 to 40 bushels of lime on the sod in the fall; plant with corn the following summer; next spring, sow with oats and clover; and the next summer, plow under the clover, and sow with wheat and timothy. We have a variety of soils, from a sandy loam to a stiff clay, and are certain that lime will pay on all or any of them. Some of the best farmers in our County commenced liming when the lime cost 25 cts. a bushel, and their farms are ahead yet, more in value, I judge, than the lime cost. The man who first commences using lime, will get so far ahead, while his neighbors are looking on, that they will never catch up."

Another correspondent in Hunterdon Co., N. J., writes: "Experience has taught me that the best and most profitable mode of applying lime is on grass land. If the grass seed is sown in the fall with the wheat or rye, which is the common practice with us in New Jersey, as soon as the harvest comes off the next year, we apply the lime with the least delay, and while fresh slacked and in a dry and mealy state. It can be spread more evenly on the ground, and is in a state to be more readily taken up by the fine roots of the plants, than if allowed to get wet and clammy. It is found most beneficial to keep it as near the surface of the ground as practicable, as the specific gravity or weight of this mineral manure is so great, that we soon find it too deep in the ground for the fibrous roots of plants to derive the greatest possible benefit from its use. With this method of application are connected several advantages. The lime can be hauled in the fall, after the busy season is over, and when spread on the sod in this way, comes in more immediate contact with the grass and grass-roots than when the land is first plowed. In fields that have been limed in part in this manner, and then plowed, and lime applied to the remainder at the time of planting with corn, I always observe a great difference in the corn-crop; and in plowing up the stubble the next season, the part limed on the sod is much mellower than that limed after the sod was broken, presenting a rich vegetable mould not observed in the other part of the field."

A farmer in Chester Co., Pa., also prefers to apply lime to newly-seeded grass or clover. He puts on 100 bushels of slaked lime per acre, either in the fall or in the spring, as most convenient. He limes one field every year, and as the farm is laid off into eleven fields, all the land receives a dressing of lime once in eleven years.

In some sections of the country, where lime has been used for many years, it is possible that part of the money might better be used in the purchase of guano, phosphates, fish-manure, etc.; while in this section, where we seldom use lime, we might find it greatly to our interest to give our land an occasional dressing of lime.

The value of quick-lime as a manure is not merely in supplying an actual constituent of the plant. If it was, a few pounds per acre would be sufficient. Its value consists in changing the chemical and physical character of the soil—in developing the latent mineral plant-food, and in decomposing and rendering available organic matter, and in forming compounds which attract ammonia from the atmosphere. It may be that we can purchase this ammonia and other plant-food cheaper than we can get it by using lime. It depends a good deal on the nature and composition of the soil. At present, this question can not be definitely settled, except by actual trial on the farm. In England, where lime was formerly used in large quantities, the tendency for some time has been towards a more liberal and direct use of ammonia and phosphates in manures, rather than to develop them out of the soil by the use of lime. A judicious combination of the two systems will probably be found the most profitable.

Making composts with old sods, lime, and barn-yard manure, is a time-honored practice in Europe. I have seen excellent results from the application of such a compost on meadow-land. The usual plan is, to select an old hedge-row or headland, which has lain waste for many years. Plow it up, and cart the soil, sods, etc., into a long, narrow heap. Mix lime with it, and let it lie six months or a year. Then turn it, and as soon as it is fine and mellow, draw it on to the land. I have assisted at making many a heap of this kind, but do not recollect the proportion of lime used; in fact, I question if we had any definite rule. If we wanted to use lime on the land, we put more in the heap; if not, less. The manure was usually put in when the heap was turned.

Dr. Vœlcker analyzed the dry earth used in the closets at the prison in Wakefield, England. He found that:

	Nitrogen.	*Phosphoric Acid.*
10 tons of dry earth before using contained...........	62 lbs.	36 lbs.
10 tons of dry earth after being used once contained...	74 "	50 "
10 tons of dry earth after being used twice contained..	84 "	88 "
10 tons of dry earth after being used thrice contained.	102 "	102 "

After looking at the above figures, the Deacon remarked: "You say 10 tons of dry earth before being used in the closet contained 62 lbs. of nitrogen. How much nitrogen does 10 tons of barn-yard manure contain?"

"That depends a good deal on what food the animals eat. Ten tons of average fresh manure would contain about 80 lbs. of nitrogen."

"Great are the mysteries of chemistry!" exclaimed the Deacon. "Ten tons of dry earth contain almost as much nitrogen as 10 tons of barn-yard manure, and yet you think that nitrogen is the most valuable thing in manure. What shall we be told next?"

"You will be told, Deacon, that the nitrogen in the soil is in such a form that the plants can take up only a small portion of it. But if you will plow such land in the fall, and expose it to the disintegrating effects of the frost, and plow it again in the spring, and let the sun and air act upon it, more or less of the organic matter in the soil will be decomposed, and the nitrogen rendered soluble. And then if you sow this land to wheat after a good summer-fallow, you will stand a chance of having a great crop."

This dry earth which Dr. Vœlcker analyzed appeared, he says, "to be ordinary garden soil, containing a considerable portion of clay." After it had been passed once through the closet, one ton of it was spread on an acre of grass-land, which produced 2 tons 8 cwt. of hay. In a second experiment, one ton, once passed through the closet, produced 2 tons 7 cwt. of hay per acre. We are not told how much hay the land produced without any dressing at all. Still we may infer that this top-dressing did considerable good. Of one thing, however, there can be no doubt. This one ton of earth manure contained only $1\frac{1}{4}$ lb. more nitrogen and $1\frac{1}{2}$ lb. more phosphoric acid than a ton of the dry earth itself. Why then did it prove so valuable as a top-dressing for grass? I will not say that it was due solely to the decomposition of the nitrogenous matter and other plant-food in the earth, caused by the working over and sifting and exposure to the air, and to the action of the night-soil. Still it would seem that, so far as the beneficial effect was due to the supply of plant-food, we must attribute it to the earth itself rather than to the small amount of night-soil which it contained.

It is a very common thing in England, as I have said before, for farmers to make a compost of the sods and earth from an old hedge-row, ditch, or fence, and mix with it some lime or barn-yard manure. Then, after turning it once or twice, and allowing it to remain in the heap for a few months, to spread it on meadow-land. I have seen great benefit apparently derived from such a top-dressing. The young grass in the spring assumed a rich, dark green color. I have observed the same effect where coal-ashes were spread on grass-land; and I have thought that the apparent benefit was due largely to the material acting as a kind of mulch, rather than to its supplying plant-food to the grass.

I doubt very much whether we can afford to make such a compost of earth with lime, ashes, or manure in this country. But I feel sure that those of us having rich clay land containing, in an inert form, as much nitrogen and phosphoric acid as Dr. Vœlcker found in the soil to be used in the earth-closet at Wakefield, can well afford to stir it freely, and expose it to the disintegrating and decomposing action of the atmosphere.

An acre of dry soil six inches deep weighs about 1,000 tons; and consequently an acre of such soil as we are talking about would contain 6,200 lbs. of nitrogen, and 3,600 lbs. of phosphoric acid. In other words, it contains to the depth of only six inches as much nitrogen as would be furnished by 775 tons of common barn-yard manure, and as much phosphoric acid as 900 tons of manure. With such facts as these before us, am I to blame for urging farmers to cultivate their land more thoroughly? I do not know that my land or the Deacon's is as rich as this English soil; but, at any rate, I see no reason why such should not be the case.

CHAPTER XXIX.

MANURES FOR BARLEY.

Messrs. Lawes and Gilbert have published the results of experiments with different manures on barley grown annually on the same land for twenty years in succession. The experiments commenced in 1852.

The soil is of the same general character as that in the field on the same farm where wheat was grown annually for so many years, and of which we have given such a full account. It is what we should call a calcareous clay loam. On my farm, we have what the men used to call "clay spots." These spots vary in size from two acres down to the tenth of an acre. They rarely produced even a fair crop of corn or potatoes, and the barley was seldom worth harvesting. Since I have drained the land and taken special pains to bestow extra care in plowing and working these hard and intractable portions of the fields, the "clay spots" have disappeared, and are now nothing more than good, rather stiff, clay loam, admirably adapted for wheat, barley, and oats, and capable of producing good crops of corn, potatoes, and mangel-wurzels.

The land on which Mr. Lawes' wheat and barley experiments were made is not dissimilar in general character from these "clay spots." If the land was only half-worked, we should call it clay; but being thoroughly cultivated, it is a good clay loam. Mr. Lawes describes it as "a somewhat heavy loam, with a subsoil of raw, yellowish red clay, but resting in its turn upon chalk, which provides good natural drainage."

The part of the field devoted to the experiments was divided into 24 plots, about the fifth of an acre each.

Two plots were left without manure of any kind.

One plot was manured every year with 14 tons per acre of farmyard manure, and the other plots "with manures," to quote Dr. Gilbert, "which respectively supplied certain constituents of farmyard manure, separately or in combination."

In England, the best barley soils are usually lighter than the best wheat soils. This is probably due to the fact that barley usually follows a crop of turnips—more or less of which are eaten off on the land by sheep. The trampling of the sheep compresses the soil, and makes even a light, sandy one firmer in texture.

In this country, our best wheat land is also our best barley land, *provided* it is in good heart, and is very thoroughly worked.

It is no use sowing barley on heavy land half worked. It will do better on light soils; but if the clayey soils are made fine and mellow, they produce with us the best barley.

In chemical composition, barley is quite similar to wheat. Mr. Lawes and Dr. Gilbert give the composition of a wheat-crop of 30 bushels per acre, 1,800 lbs. of grain, and 3,000 lbs. of straw; and of a crop of barley, 40 bushels per acre, 2,080 lbs. grain, and 2,500 lbs. of straw, as follows:

	In Grain.		*In Straw.*		*In Total Produce.*	
	Wheat.	*Barley.*	*Wheat.*	*Barley.*	*Wheat.*	*Barley.*
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Nitrogen	32.	33.	13.	12.	45.	45.
Phosphoric acid.	16.	17.	7.	5.	23.	22.
Potash	9.5	11.5	20.5	18.5	30.	30.
Lime	1.	1.5	9.	10.5	10.	12.
Magnesia	3.5	4.	3.	2.5	6.5	6.5
Silica	0.5	12.	99.5	63.	100.	75.

A few years ago, when the midge destroyed our wheat, many farmers in Western New York raised "winter barley," instead of "winter wheat," and I have seen remarkably heavy crops of this winter barley. It is not now grown with us. The maltsters would not pay as much for it as for spring barley, and as the midge troubles us less, our farmers are raising winter wheat again.

Where, as with us, we raise winter wheat and spring barley, the difference between the two crops, taking the above estimate of yield and proportion of grain to straw, would be:

1st. Almost identical composition in regard to nitrogen, phosphoric acid, potash, lime, and magnesia; but as it has more straw, the wheat-crop removes a larger amount of silica than barley.

2d. The greatest difference is in the length of time the two crops are in the ground. We sow our winter wheat the last of August, or the first and second week in September. Before winter sets in, the wheat-plant often throws out a bunch of roots a foot in length. During the winter, though the thermometer goes down frequently to zero, and sometimes 10° to 15° below zero, yet if the land is well covered with snow, it is not improbable that the roots continue to absorb more or less food from the ground, and store it up for future use. In the spring, the wheat commences to grow before we can get the barley into the ground, though not to any considerable extent. I have several times sown barley as soon as the surface-soil was thawed out five or six inches deep, but with a bed of solid frozen earth beneath.

3d. Two-rowed barley does not ripen as early as winter wheat, but our ordinary six-rowed barley is ready to harvest the same time as our winter wheat.

4th. We sow our barley usually in May, and harvest it in July. The barley, therefore, has to take up its food rapidly. If we expect a good growth, we must provide a good supply of food, and have it in the proper condition for the roots to reach it and absorb it; in other words, the land must be not only rich, but it must be so well worked that the roots can spread out easily and rapidly in search of food and water. In this country, you will find ten good wheat-growers to one good barley grower.

"That is so," said the Deacon; "but tell us about Mr. Lawes' experiments. I have more confidence in them than in your speculations. And first of all what kind of land was the barley grown on?"

"It is," said I, "rather heavy land—as heavy as what the men call 'clay-spots,' on my farm."

"And on those clay-spots," said the Deacon, "you either get very good barley, or a crop not worth harvesting."

"You have hit it exactly, Deacon," said I. "The best barley I have this year (1878) is on these clay-spots. And the reason is, that we gave them an extra plowing last fall with a three-horse plow. That extra plowing has probably given me an extra 30 bushels of barley per acre. The barley on some of the lighter portions of the field will not yield over 25 bushels per acre. On the clay-spots, it looks now (June 13) as though there would be over 50 bushels per acre. It is all headed out handsomely on the clay-spots, and has a strong, dark, luxuriant appearance, while on the sand, the crop is later and has a yellow, sickly look."

"You ought," said the Doctor, "to have top-dressed these poor, sandy parts of the field with a little superphosphate and nitrate of soda."

"It would have paid wonderfully well," said I, "or, perhaps, more correctly speaking, the loss would have been considerably less. We have recently been advised by a distinguished writer, to apply manure to our best land, and let the poor land take care of itself. But where the poor land is in the same field with the good, we are obliged to plow, harrow, cultivate, sow, and harvest the poor spots, and the question is, whether we shall make them capable of producing a good crop by the application of manure, or be at all the labor and expense of putting in and harvesting a crop of chicken-feed and weeds. Artificial manures give us a grand chance to make our crops more uniform."

"You are certainly right there," said the Doctor, "but let us examine the Rothamsted experiments on barley."

You will find the results in the following tables. The manures used, are in many respects the same as were adopted in the wheat experiments already given. The mineral or ash constituents were supplied as follows:

Potash—as sulphate of potash.

Soda—as sulphate of soda.

Magnesia—as sulphate of magnesia.

Lime—as sulphate, phosphate, and superphosphate.

Phosphoric acid—as bone-ash, mixed with sufficient sulphuric acid to convert most of the insoluble earthy phosphate of lime into sulphate and soluble superphosphate of lime.

Sulphuric acid—in the phosphatic mixture just mentioned; in sulphates of potash, soda, and magnesia; in sulphate of ammonia, etc.

Chlorine—in muriate of ammonia.

Silica—as artificial silicate of soda.

Other constituents were supplied as under:

Nitrogen—as sulphate and muriate of ammonia; as nitrate of soda; in farm-yard manure; in rape-cake.

Non-nitrogenous organic matter, yielding by decomposition, carbonic acid, and other products—in yard manure, in rape-cake.

The artificial manure or mixture for each plot was ground up, or otherwise mixed, with a sufficient quantity of soil and turf-ashes to make it up to a convenient measure for equal distribution over the land. The mixtures so prepared were, with proper precautions, sown broadcast by hand; as it has been found that the application of an exact amount of manure, to a limited area of land, can be best accomplished in that way.

The same manures were used on the same plot each year. Any exceptions to this rule are mentioned in foot-notes.

EXPERIMENTS ON THE GROWTH OF BARLEY, YEAR AFTER YEAR, ON THE SAME LAND, WITHOUT MANURE, AND WITH DIFFERENT DESCRIPTIONS OF MANURE. HOOS FIELD, ROTHAMSTED, ENGLAND.

TABLE I.—SHOWING, *taken together with the foot-notes*, THE DESCRIPTION AND QUANTITIES OF THE MANURES APPLIED PER ACRE ON EACH PLOT, IN EACH YEAR OF THE TWENTY, 1852-1871 INCLUSIVE.

[N. B. This table has reference to all the succeeding Tables].

Plots.	MANURES PER ACRE, PER ANNUM (*unless otherwise stated in the foot-notes*).	*Plots.*
1 O.	Unmanured continuously	1 O.
2 O.	3½ cwts. Superphosphate of Lime *	2 O.
3 O.	200 lbs. † Sulphate of Potass, 100 lbs. ‡ Sulphate Soda, 100 lbs. Sulphate Magnesia	3 O.
4 O.	200 lbs. † Sulphate Potass, 100 lbs. ‡ Sulphate Soda, 100 lbs. Sulphate Magnesia, 3½ cwts. Superphosphate	4 O.
1 A.	200 lbs. Ammonia-salts §	1 A.
2 A.	200 lbs. Ammonia-salts, 3½ cwts. Superphosphate	2 A.
3 A.	200 lbs. Ammonia-salts, 200 lbs. † Sulphate Potass, 100 lbs. ‡ Sulphate Soda, 100 lbs. Sulphate Magnesia	3 A.
4 A.	200 lbs. Ammonia salts, 200 lbs. † Sulphate Potass, 100 lbs. ‡ Sulphate Soda, 100 lbs. Sulphate Magnesia, 3½ cwts. Superphosphate	4 A.
‖ 1 AA.	275 lbs. Nitrate Soda	1 AA. ‖
‖ 2 AA.	275 lbs. Nitrate Soda, 3½ cwts. Superphosphate	2 AA. ‖
‖ 3 AA.	275 lbs. Nitrate Soda, 200 lbs. † Sulphate Potass, 100 lbs. ‡ Sulphate Soda, 100 lbs. Sulphate Magnesia	3 AA. ‖
‖ 4 AA.	275 lbs. Nitrate Soda, 200 lbs. † Sulphate Potass, 100 lbs. ‡ Sulphate Soda, 100 lbs. Sulphate Magnesia, 3½ cwts. Superphosphate	4 AA. ‖
‖ 1 AAS.	275 lbs. Nitrate Soda, 400 lbs. ¶ Silicate Soda	1 AAS. ‖
‖ 2 AAS.	275 lbs. Nitrate Soda, 400 lbs. ¶ Silicate Soda, 3½ cwts. Superphosphate	2 AAS. ‖
‖ 3 AAS.	275 lbs. Nitrate Soda, 400 lbs. ¶ Silicate Soda, 200 lbs. † Sulphate Potass, 100 lbs. ‡ Sulphate Soda, 100 lbs. Sulphate Magnesia	3 AAS. ‖
‖ 4 AAS.	275 lbs. Nitrate Soda, 400 lbs. ¶ Silicate Soda, 200 lbs. † Sulphate Potass, 100 lbs. ‡ Sulphate Soda, 100 lbs. Sulphate Magnesia, 3½ cwts. Superphosphate	4 AAS. ‖
** 1 C.	1000 lbs. Rape-cake	1 C. **
** 2 C.	1000 lbs. Rape-cake, 3½ cwts. Superphosphate	2 C. **
** 3 C.	1000 lbs. Rape-cake, 200 lbs. † Sulphate Potass, 100 lbs. ‡ Sulphate Soda, 100 lbs. Sulphate Magnesia	3 C. **
** 4 C.	1000 lbs. Rape-cake, 200 lbs. † Sulphate Potass, 100 lbs. ‡ Sulphate Soda, 100 lbs. Sulphate Magnesia, 3½ cwts. Superphosphate	4 C. **
†† 1 N.	275 lbs. Nitrate Soda	1 N. ††
†† 2 N.	275 lbs. Nitrate Soda (550 lbs. Nitrate for 5 years, 1853, 4, 5, 6, and 7)	2 N. ††
M.	100 lbs. ‡‡ Sulphate Soda, 100 lbs. Sulphate Magnesia, 3½ cwts. Superphosphate (commencing 1855; 1852, 3, and 4, unmanured)	M.
5 O.	200 lbs. † Sulphate Potass, 3½ cwts. Superphosphate (200 lbs. Ammonia-salts also, for the first year, 1852, only)	5 O.
5 A.	200 lbs. † Sulphate Potass, 3½ cwts. Superphosphate, 200 lbs. Ammonia-salts	5 A.
6 1	Unmanured continuously	1 6
6 2	Ashes (burnt-soil and turf)	2 6
7	14 Tons Farmyard-Manure	7

NOTES TO TABLE I.

* "3½ cwts. Superphosphate of Lime"—in all cases, made from 200 lbs. Bone-ash, 150 lbs. Sulphuric acid sp. gr. 1.7 (and water).

† Sulphate Potass—300 lbs. per annum for the first 6 years, 1852-7.

‡ Sulphate Soda—200 lbs. per annum for the first 6 years, 1852-7.

§ The "Ammonia-salts"—in all cases equal parts of Sulphate and Muriate of Ammonia of Commerce.

‖ Plots "AA" and "AAS"—first 6 years, 1852-7, instead of Nitrate of Soda, 400 lbs. Ammonia-salts per annum; next 10 years, 1858-67, 200 lbs. Ammonia-salts per annum; 1868, and since, 275 lbs. Nitrate of Soda per annum. 275 lbs. Nitrate of Soda is reckoned to contain the same amount of Nitrogen as 200 lbs. "Ammonia-salts."

¶ Plots "AAS"—the application of Silicates did not commence until 1864; in '64-5-6, and 7, 200 lbs. Silicate of Soda and 200 lbs. Silicate of Lime were applied per acre, but in 1868, and since, 400 lbs. Silicate of Soda, and no Silicate of Lime. These plots comprise, respectively, one half of the original "AA" plots, and, excepting the addition of the Silicates, have been, and are, in other respects, manured in the same way as the "AA" plots.

** 2000 lbs. Rape-cake per annum for the first 6 years, and 1000 lbs. only, each year since. †† 300 lbs. Sulphate Potass, and 3½ cwts. Superphosphate of Lime, without Nitrate of Soda, the first year (1852); Nitrate alone each year since. ‡‡ Sulphate Soda—200 lbs. per annum 1855, 6, and 7.

EXPERIMENTS ON THE GROWTH OF BARLEY, YEAR AFTER YEAR, ON
TIONS OF MANURE, HOOS

TABLE II.—DRESSED

[N.B. The double vertical lines show that there was a change in the descrip-
Table I., and foot-notes

Plots.	HARVESTS.											
	1852	1853	1854	1855	1856	1857	1858	1859	1860	1861	1862	1863
	bushels.	bush.	bush.	bus	bus	bush.	bush.	bus	bus	bus	bus	bus
1 O.	27¼	25¾	35	31	13⅞	26⅛	21⅛	13½	13¼	16¼	16½	22⅞
2 O.	28⅝	33½	40⅝	36¼	17¾	33¼	28¾	19⅝	15¾	25	21⅞	32⅜
3 O.	26⅛	27⅝	36½	34¾	16⅝	32	24¼	15⅞	15¼	18⅞	19¾	27⅝
4 O.	32¾	35⅝	42	37⅛	19¾	39¾	30⅞	19¾	18¼	29⅜	25⅛	33
Means	28¾	30⅝	38½	34¾	17	32¾	26¼	17¼	15⅝	22⅜	20¾	28⅞
1 A.	36⅞	38⅝	47¾	44½	25	38⅞	31½	15⅜	26⅝	30½	31⅜	42⅝
2 A.	38⅝	40⅛	60½	47¾	29⅛	56½	51⅜	34½	43⅜	55	48⅝	61⅝
3 A.	36	36½	50	44½	28⅜	42⅜	34¼	16⅞	28	32¾	35¼	48⅝
4 A.	40¾	38¼	60⅝	48⅜	31¾	57⅜	51½	34⅝	43½	54⅝	47⅝	55⅜
Means	38⅛	38⅜	54¾	46¼	28½	48¾	42⅛	25⅜	35⅜	43¼	40¾	52⅛
1 AA.	44½	40¾	56⅝	48	36¼	49¾	39⅜	21½	25⅜	35	31½	49
2 AA.	43¾	42¼	63¼	50⅜	31½	66½	56¼	35⅞	43¼	55¾	51	60½
3 AA.	41¾	41¼	51½	47¼	25⅜	49⅞	40⅝	20⅜	30¾	36⅞	36¼	54
4 AA.	45⅛	44½	62¾	49⅝	37⅝	64⅞	56¼	35¾	46¼	55⅞	48¾	59½
Means	43¾	42⅛	58½	48⅞	32⅝	57¾	48⅛	28⅜	36⅜	45⅞	41⅞	55¾
1 AAS.												
2 AAS.												
3 AAS.												
4 AAS.												
Means												
1 C.	39⅛	39⅞	60¾	48½	36¾	64⅛	53¾	38¾	31¾	56½	41	51⅞
2 C.	36½	36⅛	60⅝	53¼	37⅛	62¼	57⅜	41	36¾	56⅞	45	55
3 C.	33½	35¼	56½	48⅞	32⅝	60¼	52	34⅛	35¼	51⅛	36	53⅛
4 C.	38	40⅛	60¼	51¾	35⅜	62¼	57⅛	35	40¾	53⅝	45½	54½
Means	36¾	37⅞	59½	50⅝	35½	62¼	55	37¼	36⅛	54½	41⅞	53⅝
1 N.	(25⅞)	34⅜	49⅜	50	28½	47⅞	37¾	24⅞	27⅜	38¼	35½	51½
2 N.		37⅛	53¼	49⅜	42	58	43⅞	26½	29¾	41⅝	38⅜	53⅞
M.				32⅛	18¾	24½	25⅞	19½	10⅝	27⅝	23⅝	28⅛
5 O.	(36½)	27½	30¾	32⅜	19⅛	31⅛	25⅜	16½	10⅛	28⅝	17⅜	29½
5 A.	36½	40⅛	51⅞	47⅞	33⅛	54⅞	48⅛	33⅛	39	49⅜	46⅝	51½
6 { 1	29	26¼	35⅛	37¼	15⅛	34⅞	26½	17⅛	12¼	16⅝	18½	27¼
6 { 2	25⅛	27⅜	33¼	36¼	15⅞	31⅛	25¼	14¾	12⅛	17⅞	19	28⅝
7	33	36⅛	56⅜	50⅛	32⅛	51¼	55	40	41⅝	54⅜	49¾	59½

(1) Averages of 4 years, 4 years, and 8 years. (2) Averages of 9 years, last 10 years, and total 17 years. (4) Averages

THE SAME LAND, WITHOUT MANURE, AND WITH DIFFERENT DESCRIP-
FIELD, ROTHAMSTED, ENGLAND.

CORN PER ACRE—bushels.

tion, or quantity, of Manure, at the period indicated, for particulars of which see thereto, p. 231.]

Harvests.								Average Annual.			
1864	1865	1866	1867	1868	1869	1870	1871	*First ten Years, 1852–'61.*	*Second ten Years, 1862–'71.*	*Total Period 20 Years, 1852–'71.*	*Plots.*
bush.	bus	bush.	bus	bush.	bus	bus	bus	bushels.	bush.	bushels.	
24	18	15⅞	17⅛	15⅝	15⅛	13½	16¾	22⅜	17½	20	1 O.
30¼	22½	22⅜	24⅝	18½	18¼	18	23⅓	27⅞	23¼	25½	2 O.
26⅛	22	19⅛	17	14¼	18¾	16¾	19⅝	24¾	20⅛	22⅜	3 O.
33¼	24⅜	24	20⅞	17⅝	22¼	18½	25	30½	24⅜	27½	4 O.
28⅜	21¾	20⅜	19⅞	16½	18⅝	16¾	21⅛	26⅜	21¼	23⅞	Means
38⅞	29⅞	27⅛	30⅝	20⅜	27⅞	27¾	36⅜	33⅝	31¼	32½	1 A.
58½	48⅜	50½	44	37⅝	48	41½	45⅛	45⅝	48⅜	47	2 A.
43⅞	33¼	27½	33	25	34¾	30⅞	38⅛	35	35	35	3 A.
55⅝	46½	47	43⅞	34⅝	49¼	38	46½	46⅛	46⅜	46¼	4 A.
49⅛	39½	38⅛	37⅞	29⅜	39⅞	34½	41½	40⅛	40¼	40¼	Means
41¾	33¾	29⅛	29¾	27	32⅛	29¼	39⅓	39¾	34¼	37	1 AA.
56⅞	47½	50⅞	44¼	44	48¼	46¼	46½	48⅞	49⅝	49¼	2 AA.
44⅝	34⅛	29¾	32⅞	27½	33⅞	32⅜	36⅛	38⅝	36⅛	37⅜	3 AA.
56⅜	48⅞	50⅞	45	45⅜	49⅞	44½	46	49⅞	49½	49¾	4 AA.
49⅞	41⅛	40⅛	38	36	41	38⅛	42	44¼	42⅜	43⅜	Means
44⅛	34⅞	37⅞	32¼	29⅜	34¾	35	48⅛	37¼	36⅞	37	1 AAS.
54⅞	47¼	51⅛	44	44⅞	49⅞	44¾	49½	(1) 49¼	47¼	48¼ (1)	2 AAS.
50	41	41⅞	39½	36⅜	40½	42¾	48⅜	43⅛	42	42⅝	3 AAS.
59⅛	50½	50¾	45¼	46⅝	51¾	47¼	48⅞	51⅜	48⅝	50	4 AAS.
52	43⅜	45⅜	40¼	39⅜	44¼	42½	48¾	45¼	43¾	44½	Means
48⅛	45	45⅞	38⅝	37	42½	41¾	44	47	43⅝	45¼	1 C.
51¾	46⅛	47½	45½	35¼	48¼	41¾	41¾	47¾	45¾	46¾	2 C.
49⅜	48¾	43⅞	38⅞	35⅛	43⅝	38½	45⅜	44	43¼	43⅝	3 C.
53	48⅛	48⅝	42⅝	36¼	52⅛	43¾	47½	47⅜	47¼	47⅜	4 C.
50½	47	46½	41⅜	35⅞	46⅝	41½	44⅝	46½	45	45¾	Means
40¾	37	34⅜	33	25½	35¼	34¾	43⅛	(2) 37⅝	37⅛	37⅜ (2)	1 N.
46¼	39⅞	41	36⅜	25⅜	38⅝	40¼	45⅜	42⅜	40½	41⅜	2 N.
25⅞	19¾	19	20½	14¾	16⅝	16⅛	22⅛	(3) (22⅝	20⅝	21½) (3)	M.
26½	23	22½	19½	15	23⅜	14½	20	(4) (24⅝	21⅛	22¾) (4)	5 O.
50¾	48¼	43⅞	34⅞	36⅛	49⅞	41¾	44¼	43⅜	44¾	44⅛	5 A.
25⅛	21	16⅛	16⅜	15¼	14⅞	15¼	18¾	25	18⅞	22	1 } 6
25⅛	19¼	17¼	19¾	15⅞	15⅜	15⅛	24¼	23⅞	20	21⅞	2 } 6
62	52¾	53⅛	45⅝	43⅝	46⅞	47½	54¼	45	51½	48¼	7

(1853–'61), last 10 years, and total 19 years. (3) Averages of 7 years (1855–'61), of 9 years (1853–'61), last 10 years, and total 19 years.

EXPERIMENTS ON THE GROWTH OF BARLEY, YEAR AFTER YEAR, ON THE
MANURE. HOOS

TABLE III.—WEIGHT PER

(N.B. The double vertical lines show that there was a change in the description,
Table I., and foot notes,

Plots.	HARVESTS.											
	1852'	1853	1854	1855	1856	1857	1858	1859	1860	1861	1862	1863
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1 O.	52.1	51.4	53.6	52.4	49.1	52.0	53.0	49.0	50.8	52.3	50.3	53.6
2 O.	52.6	52.6	54.0	52.5	46.5	52.8	54.0	52.0	50.5	53.3	52.0	54.2
3 O.	52.5	51.9	53.6	52.9	48.5	52.5	53.5	49.5	50.3	52.8	51.8	54.5
4 O.	51.5	52.1	54.0	53.1	47.0	53.7	54.0	52.5	51.3	54.0	52.0	54.8
Means	52.2	52.0	53.8	52.7	47.8	52.8	53.6	50.8	50.7	53.1	51.5	54.3
1 A.	50.7	52.4	53.6	51.8	48.5	51.9	53.0	47.5	50.8	51.5	49.4	53.6
2 A.	50.5	52.5	54.3	51.3	46.3	54.3	53.8	51.0	51.0	53.5	53.5	55.3
3 A.	50.9	52.6	54.0	52.2	49.1	52.1	54.0	47.5	50.8	51.5	50.5	54.3
4 A.	51.4	53.1	54.3	52.0	46.4	54.8	54.0	51.0	51.1	54.0	54.0	56.5
Means	50.9	52.7	54.1	51.8	47.6	53.3	53.7	49.3	50.9	52.6	51.9	54.9
1 AA.	49.1	51.3	52.8	50.6	48.3	52.0	53.5	47.5	50.7	51.8	50.0	53.9
2 AA.	49.5	51.7	52.4	50.1	46.1	53.5	53.3	50.7	51.3	53.5	54.4	55.7
3 AA.	50.6	51.3	53.1	50.2	47.3	52.1	53.9	47.5	50.4	51.5	51.5	54.5
4 AA.	50.6	51.4	52.1	48.9	45.4	53.9	53.5	50.5	51.0	53.5	54.0	56.4
Means	50.0	51.4	52.6	50.0	46.8	52.9	53.6	49.1	50.9	52.6	52.5	55.1
1 AAS.												
2 AAS.												
3 AAS.												
4 AAS.												
Means												
1 C.	51.7	51.3	52.9	50.5	46.1	53.2	53.5	52.0	52.0	54.0	54.5	56.3
2 C.	51.8	51.6	52.8	50.0	47.3	53.8	52.8	51.5	51.5	54.1	55.3	56.4
3 C.	51.3	51.5	52.6	50.6	46.6	54.1	53.5	51.7	51.8	53.5	53.5	56.8
4 C.	51.4	50.4	52.8	49.5	46.3	54.1	53.1	51.0	51.1	54.3	54.0	56.7
Means	51.6	51.2	52.8	50.2	46.6	53.8	53.2	51.6	51.6	54.0	54.3	56.6
1 N.	(51.7)	51.3	53.3	52.0	50.0	52.9	53.5	48.0	51.0	52.0	51.5	53.4
2 N.		49.7	53.1	50.1	48.4	53.0	54.0	48.5	51.1	51.8	51.3	53.9
M.				52.6	49.3	52.6	53.6	49.5	51.0	53.8	52.8	53.8
5 O.	(51.0)	51.8	53.1	52.6	47.5	53.4	54.0	51.0	51.0	53.3	51.5	54.1
5 A.	51.0	52.3	53.8	51.5	46.6	54.5	54.0	51.0	51.2	53.0	52.0	55.6
6 { 1.	52.0	50.3	52.8	52.5	50.0	52.3	53.1	48.5	51.3	52.0	51.8	54.0
6 { 2.	53.0	50.9	53.6	52.6	50.0	52.3	53.1	47.5	51.0	52.0	52.0	54.1
7	52.8	51.6	53.9	52.9	47.1	54.2	54.5	52.5	52.1	54.8	54.8	57.2

(1) Averages of 4 years, 4 years, and 8 years. (2) Averages of 9 years
last 10 years, and total 17 years. (4) Averages

SAME LAND, WITHOUT MANURE, AND WITH DIFFERENT DESCRIPTIONS OF FIELD, ROTHAMSTED.

BUSHEL OF DRESSED CORN—lbs.

or quantity, of Manure, at the period indicated, for particulars of which see thereto, p. 231.]

HARVESTS.								AVERAGE ANNUAL.			
1864	1865	1866	1867	1868	1869	1870	1871	*First ten Years, 1852–'61.*	*Second ten Years, 1862–'71.*	*Total Period 20 Years, 1852–'71.*	*Plots.*
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	
55.7	53.9	51.1	51.8	54.3	52.4	52.9	55.0	51.6	53.1	52.3	1 O.
56.8	53.8	53.2	53.9	55.8	54.3	53.6	56.0	52.0	54.4	53.2	2 O.
56.9	54.5	52.3	52.9	55.7	54.7	54.3	55.4	51.8	54.3	53.0	3 O.
57.3	54.0	52.7	53.6	55.3	54.6	55.6	55.6	52.3	54.6	53.4	4 O.
56.7	54.1	52.3	53.1	55.3	54.0	54.1	55.5	52.0	54.1	53.0	Means
55.4	53.8	50.9	51.3	53.3	52.4	54.6	55.6	51.2	53.0	52.1	1 A.
57.0	52.7	54.4	54.1	54.6	57.0	57.2	55.0	51.8	55.1	53.5	2 A.
56.4	54.7	52.1	51.9	54.8	54.6	55.4	56.1	51.5	54.1	52.8	3 A.
57.6	53.5	54.7	54.3	55.6	57.4	57.1	56.5	52.2	55.7	54.0	4 A.
56.6	53.7	53 0	52.9	54.6	55.4	56.1	55.8	51.6	54.5	53.1	Means
55.5	53.5	50.9	52.4	53.7	53.1	54.5	54.1	50.8	53.2	52.0	1 AA.
57.2	52.3	55.0	54.1	55.6	57.2	56.9	55.9	51.2	55.4	53.3	2 AA.
56.5	54.8	51.4	51.9	55.1	53.7	54.6	54.3	50.8	53.8	52.3	3 AA.
57.6	53.3	55.4	54.6	56.0	57.1	57.1	56.3	51.1	55.8	53.4	4 AA.
56.7	53.5	53.2	53.3	55.1	55.3	55.8	55.2	51.0	54.6	52.8	Means
56.1	54.2	51.8	53.5	54.2	54.8	55.0	54.6	(1) 53.9	54.6	54.3 (1)	1 AAS.
57.2	52.4	55.6	55.1	56.2	57.4	57.4	55.6	(1) 55.1	56.7	55.9 (1)	2 AAS.
57.2	54.8	52.5	53.0	55.5	56.6	55.9	53.8	(1) 54.4	55.5	55.0 (1)	3 AAS.
57.0	53.1	55.3	54.1	56.2	57.8	57.8	55.4	(1) 54.9	56.8	55.8 (1)	4 AAS.
56.9	53.6	53.8	53.9	55.5	56.7	56.5	54.9	54.6	55.9	55.2	Means
57.1	53 8	55.1	54.4	56.2	56.7	57.5	56.3	51.7	55.8	53.8	1 C.
57.0	53.3	55.7	55.0	56.1	57.1	57.8	56.4	51.7	56.0	53.9	2 C.
57.3	53.3	55.3	54.7	55.8	57.1	57.6	56.3	51.7	55.8	53.7	3 C.
57.2	53.5	55.6	54.8	55.4	57.4	58.0	56.4	51.4	55.9	53.6	4 C.
57.1	53.5	55.4	54.7	55.9	57.1	57.7	56.4	51.6	55.9	53.8	Means
56.0	54.1	52.0	52.9	52.8	54.3	55.6	54.6	(2) 51.6	53.7	52.7 (2)	1 N.
56.5	53.8	52.8	52.7	55.5	54.8	55.8	54.6	(2) 51.1	54.2	52.7 (2)	2 N.
56.3	54.4	52.9	53.9	54.0	54.0	55.3	55.0	(3) (51.8	54.2	53.2) (3)	M.
57.6	54.5	53.4	54.0	56.4	55.6	55.9	55.1	(4) (52.0	54.8	53.4) (4)	5 O.
57.5	54.1	54.8	55.2	57.5	57.5	57.3	55.5	51.9	55.7	53.8	5 A.
56.0	53.9	51.3	52.0	53.5	52.8	54.0	55.4	51.5	53.5	52.5	1 } 6
55.8	53.9	51.8	52.5	53.8	52.9	54.6	54.9	51.6	53.6	52.6	2 } 6
57.4	54.4	54.9	54.8	57.1	56 4	57.1	56.6	52.6	56.0	54.3	7

(1853–'61), last 10 years, and total 19 years. (3) Averages of 7 years (1855–'61), of 9 years (1853–'61), last 10 years, and total 19 years.

EXPERIMENTS ON THE GROWTH OF BARLEY, YEAR AFTER YEAR, ON THE MANURE. HOOS

TABLE IV.—OFFAL

[N.B. The double vertical lines show that there was a change in the description, *Table I.*, and foot-notes

Plots.	HARVESTS.											
	1852	1853	1854	1855	1856	1857	1858	1859	1860	1861	1862	1863
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1. O.	164	225	84	144	131	93	86	110	78	88	64	49
2. O.	100	101	101	69	58	106	103	159	84	78	114	58
3. O.	183	151	64	76	129	61	96	85	78	88	73	54
4. O.	136	160	105	94	88	53	108	160	74	58	117	57
Means	146	159	89	96	102	78	98	129	78	78	92	55
1. A.	218	253	201	138	219	113	98	184	150	170	269	116
2. A.	260	244	150	184	121	88	114	274	159	130	191	99
3. A.	252	336	197	177	180	91	96	175	115	109	269	108
4. A.	273	274	138	142	125	70	117	253	150	110	150	81
Means	251	277	172	160	161	91	106	222	143	130	220	101
1. AA.	299	303	326	204	310	135	88	215	109	173	296	110
2. AA.	315	251	329	181	233	133	134	320	118	190	133	143
3. AA.	318	236	334	212	290	108	118	265	122	138	364	95
4. AA.	246	301	273	150	176	183	143	285	141	179	191	66
Means	294	273	316	187	252	140	121	271	123	170	246	103
1 AAS.												
2 AAS.												
3 AAS												
4 AAS.												
Means												
1 C.	170	268	178	219	173	135	103	225	120	154	154	85
2 C.	164	376	238	195	161	169	148	171	156	150	128	109
3 C.	190	296	248	183	189	156	105	236	115	204	190	71
4 C.	144	277	227	222	205	168	125	350	153	204	174	66
Means	167	304	223	205	182	157	120	246	136	178	161	83
1 N.	(94)	283	109	123	245	99	119	205	146	225	245	120
2 N.		228	286	224	193	151	110	235	179	190	216	114
M.				36	94	90	84	85	75	78	198	46
5 O.	(173)	68	113	50	96	101	71	110	73	73	193	41
5 A.	173	210	170	126	151	68	154	168	193	188	210	81
6 { 1	120	200	144	116	152	72	84	121	88	73	75	51
6 { 2	118	161	119	73	125	105	81	127	95	67	194	65
7	101	269	86	109	141	134	121	260	147	190	208	66

(1) Averages of 4 years, 4 years, and 8 years. (2) Averages of 9 years last 10 years, and total 17 years. (4) Averages

SAME LAND, WITHOUT MANURE, AND WITH DIFFERENT DESCRIPTIONS OF FIELD, ROTHAMSTED.

CORN PER ACRE—lbs.

or quantity, of Manure, at the period indicated, for particulars of which, see thereto, p. 231.]

Harvests. 1864	1865	1866	1867	1868	1869	1870	1871	Average Annual. First ten Years, 1852–'61.	Second ten Years, 1862–'71.	Total Period 20 Years, 1852–'71.	Plots.
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	
42	47	41	90	21	44	31	48	120	48	84	1 O.
69	38	21	53	29	89	18	33	96	52	74	2 O.
43	38	38	64	27	70	18	35	101	46	74	3 O.
41	28	55	60	25	69	26	48	104	53	78	4 O.
49	38	39	67	25	68	23	41	105	50	78	Means
99	58	94	115	49	139	23	105	174	107	141	1 A.
63	84	64	76	38	113	26	189	172	94	133	2 A.
83	51	106	94	34	95	24	89	173	95	134	3 A.
110	60	63	71	50	21	27	146	165	78	122	4 A.
89	63	82	89	43	92	25	132	171	94	133	Means
110	64	148	110	46	64	33	133	216	111	164	1 AA.
50	113	111	69	46	89	24	168	220	95	158	2 AA.
76	48	103	106	59	111	36	133	214	113	164	3 AA.
46	76	133	119	43	78	30	90	208	87	148	4 AA.
71	75	124	101	48	86	31	131	215	102	159	Means
94	55	88	85	49	121	33	94	(1) 81	74	77 (1)	1 AAS.
53	86	96	66	64	60	23	153	(1) 75	75	75 (1)	2 AAS.
70	50	141	79	39	136	29	130	(1) 85	84	85 (1)	3 AAS.
93	70	80	93	46	125	26	175	(1) 84	93	89 (1)	4 AAS.
77	65	101	81	50	111	28	138	81	82	82	Means
78	83	104	109	43	69	25	78	175	83	129	1 C.
92	44	89	89	64	111	24	88	193	84	138	2 C.
90	66	94	91	39	91	37	141	192	91	142	3 C.
123	69	128	72	42	67	28	124	208	89	149	4 C.
96	66	104	90	47	85	28	108	192	87	139	Means
74	98	124	119	61	150	33	99	(2) 173	112	141 (2)	1 N.
95	84	104	88	35	98	33	171	(2) 199	104	149 (2)	2 N.
58	69	44	56	26	61	25	58	(3) (77	64	69) (3)	M.
78	35	48	56	20	75	23	41	(4) (84	61	72) (4)	5 O.
91	94	53	74	33	63	30	144	160	87	124	5 A.
51	45	72	103	27	71	26	50	117	57	87	1 } 6
54	47	51	83	21	57	23	41	107	64	85	2 } 6
117	56	148	111	48	100	26	171	156	105	130	7

(1853-61), last 10 years, and total 19 years. (3) Averages of 7 years (1855–'61), of 9 years (1853-'61), last 10 years, and total 19 years.

EXPERIMENTS ON THE GROWTH OF BARLEY, YEAR AFTER YEAR, ON THE
MANURE. HOOS

TABLE V.—STRAW

N.B. The double vertical lines show that there was a change in the descrip-
Table 1., and foot-notes

Plots.	1852	1853	1854	1855	1856	1857	1858	1859	1860	1861	1862	1863
	HARVESTS.											
	Cwts.	cwts.	cwts.	cwt	cwt	cwts.	cwts.	cwt	cwt	cwt	cwt	cwt
1 O.	16⅝	18	21¾	17⅝	8¾	12¾	10⅞	9⅛	7½	11	9¾	11⅜
2 O.	16½	17⅛	23¼	17¾	8¾	15⅝	14⅞	12¼	8⅞	13¼	12⅞	15⅝
3 O.	16½	17¼	20⅞	17½	9⅛	15	12¼	9¾	8½	11½	10⅞	13⅜
4 O.	19½	20½	23⅛	18	9⅜	17⅛	16⅛	12¼	9⅛	15⅜	13½	15⅜
Means	17¼	18¼	22¼	17⅝	9	15⅛	13½	10⅝	8⅝	12¾	11½	13⅞
1 A.	22⅞	23¾	30¼	24⅛	17⅛	17¾	15½	11½	14⅞	19⅝	20⅜	21⅜
2 A.	26	25½	40⅞	29⅜	21½	26¾	28¾	24⅞	25¼	29¾	32⅜	34
3 A.	23⅝	25⅛	33¾	27½	17⅞	21⅜	17⅞	13½	16¼	21½	23¼	26¼
4 A.	27⅞	26⅝	40½	31	21¼	27⅞	29⅜	27¼	26⅝	30½	31⅝	32
Means	25⅛	25¼	36⅜	28	19½	23½	22⅛	19¼	20¾	25⅜	26¾	28⅜
1 AA.	26⅞	26⅛	37⅞	32⅛	24½	23½	19⅛	14½	13½	22	21¼	25⅛
2 AA.	28⅜	28⅜	44⅜	38⅝	31⅝	32⅞	32⅝	26½	24¼	31⅝	31½	32½
3 AA.	26⅜	27¼	37⅞	34	26⅛	26	22⅛	16⅛	18⅛	24⅛	24¾	27⅞
4 AA.	28⅜	31⅝	49	39⅞	33	36¼	35¾	30⅝	29	33⅝	33⅛	34¾
Means	27½	28⅜	42¼	36⅛	28¾	29⅝	27½	21⅞	21¼	27⅞	27⅝	30
1 AAS.												
2 AAS.												
3 AAS.												
4 AAS.												
Means												
1 C.	24⅝	26⅞	43¼	36⅛	26	33⅛	30¾	26⅞	17⅞	27⅞	26	28⅝
2 C.	23¾	25⅝	44⅛	36⅛	31½	33⅛	33⅞	28¾	20⅝	30⅜	27¼	30⅛
3 C.	21⅞	25¼	41¼	35⅞	26½	30⅞	30¾	25⅝	20⅛	30¾	23⅞	29⅞
4 C.	24⅛	27½	42⅛	37⅝	30½	33⅛	35	29½	22¾	31	28⅞	30¾
Means	23½	26¼	42¾	36½	28⅝	32⅝	32⅝	27¾	20⅜	30	26½	29⅞
1 N.	(15¼)	23⅛	33⅜	27	19⅝	24⅝	20⅛	18¾	16¾	27¼	24¼	30¼
2 N.		25⅜	38¼	33¼	28¾	32	23⅝	21¼	18⅝	29⅝	24¾	29⅞
M.				15¼	10⅝	10⅜	12⅜	10⅞	7¼	15⅛	14½	19½
5 O.	(25⅛)	15¾	20¼	14⅝	10⅜	13¼	12½	10½	6⅞	17½	10½	15¼
5 A.	25⅛	24	35¾	31	22¾	27⅝	28⅝	26⅛	25½	31⅞	31⅝	34
6 { 1	17⅛	16½	22½	18⅛	9¼	16⅛	12	11¼	7½	9⅞	10⅜	13½
6 { 2	14⅛	15⅞	20¾	16¾	9½	14⅝	11⅜	10	7¾	10	11⅝	14⅜
7	18½	22¾	37¼	27½	19¾	23⅝	31⅜	28½	25⅜	31⅝	34¼	33⅛

(1) Averages of 4 years, 4 years, and 8 years. (2) Averages of 9 years
last 10 years, and total 17 years. (4) Averages

SAME LAND, WITHOUT MANURE, AND WITH DIFFERENT DESCRIPTIONS OF FIELD, ROTHAMSTED.

(AND CHAFF) PER ACRE—cwts.

tion, or quantity, of Manure, at the period indicated, for particulars of which see thereto, p. 231.]

Harvests.								Average Annual.			
1864	1865	1866	1867	1868	1869	1870	1871	*First ten Years, 1852–'61.*	*Second ten Years, 1862–'71.*	*Total Period 20 Years, 1852–'71.*	*Plots.*
cwts.	cwt	cwts.	cwt	cwts.	cwt	cwt	cwt	cwts.	cwts.	cwts.	
12¾	8⅛	9½	10¼	11⅝	11	6⅝	11	13⅜	10¼	11¾	1 O.
15⅝	9⅛	12⅝	12¼	9⅜	10⅜	8	12¼	14⅞	11⅞	13⅜	2 O.
13⅝	9¾	10¼	10⅛	8⅝	11	8½	11¼	13⅞	10¾	12¼	3 O.
16¾	10	12⅞	12	10⅛	12⅞	9⅜	14	16⅛	12⅝	14⅜	4 O.
14⅝	9¼	11¼	11⅛	9⅞	11¼	8⅛	12⅛	14½	11⅜	12⅞	Means
20⅜	13	15⅜	17¼	12¼	18¼	12½	23⅛	19¾	17⅜	18½	1 A.
32½	21⅝	28⅛	28⅝	19⅜	32	17⅞	28⅛	27⅞	27½	27⅝	2 A.
19¼	16	16¾	19⅜	14⅞	20¾	15	25⅜	21⅞	19¾	20¾	3 A.
34⅞	22½	27⅜	25½	20⅞	34⅜	18⅝	32½	28⅞	28	28½	4 A.
26¾	18¼	21¾	22⅝	16¾	26⅜	16	27¼	24½	23⅛	23¾	Means
23¼	16	17¾	17⅛	14½	21½	17⅞	26¾	24	20⅛	22⅛	1 AA.
33⅛	23	28⅛	30⅞	21⅞	34⅞	23¾	32⅛	31⅞	29⅛	30½	2 AA.
26⅞	17	18⅛	20¾	16¼	22¾	20⅞	25⅜	25¾	22¼	24	3 AA.
37¼	24⅞	28¼	28⅜	25⅝	38⅛	18¼	32⅝	34¾	30⅛	32⅜	4 AA.
30⅛	20¼	23⅛	24¼	19⅝	29¼	20¼	29¼	29	25⅜	27¼	Means
26⅛	22⅜	20⅝	18½	16⅞	23¾	17	29¾	(1) 21⅞	21⅞	21⅞ (1)	1 AAS.
33½	23¼	30¼	29½	25¼	37⅛	20⅛	36⅛	29⅛	29⅝	29⅜	2 AAS.
30¼	20⅜	25	23⅜	22	30⅝	20½	31⅛	24¾	26⅛	25⅜	3 AAS.
40¾	25½	29½	28¼	26⅝	42½	20¾	38	31	32	31½	4 AAS.
32⅝	22⅞	26⅜	24⅞	22⅝	33½	19⅝	33¾	26⅝	27⅜	27	Means
26⅛	21½	24⅛	25½	19⅛	27	17¼	27½	29⅜	24¼	26⅞	1 C.
31⅞	21⅞	24½	25⅝	19⅝	33⅛	17⅞	27⅞	30⅞	26	28⅜	2 C.
31	22	24⅜	22¼	10¾	30½	18⅜	30⅞	28⅞	25¼	27⅛	3 C.
34⅞	22	27⅝	24¼	21⅛	35⅛	20⅜	32	31¼	27¾	29½	4 C.
31	21⅞	25⅛	24⅜	19⅞	31⅜	18½	29⅝	30⅛	25¾	28	Means
24⅛	18½	21⅛	21⅛	18⅞	24	13¼	29¼	(2) 23⅜	22½	22⅞ (2)	1 N.
27¾	21½	23⅞	21¾	17⅛	27⅝	19⅛	31½	27⅞	24½	26⅛	2 N.
13⅞	9⅜	12⅜	12	10⅛	11⅝	8⅞	14¾	(3) (11¾	12¾	12⅜) (3)	M.
14⅞	10¾	10⅝	10⅜	8½	15½	4⅜	13⅛	(4) (13⅝	11⅜	12⅜) (4)	5 O.
33⅞	24⅞	28	22⅜	20⅝	36⅛	21⅜	29⅝	27⅞	28¼	28	5 A.
13⅝	8¾	10½	9⅜	10½	9⅞	7¾	13	14	10¾	12⅜	1 } 6
13⅞	8⅞	9½	10⅞	10⅞	10⅜	7⅞	13⅝	13	11¼	12⅛	2 } 6
37⅜	25⅜	31½	27⅛	24½	28¾	19¾	37⅛	26⅝	29⅞	28¼	7

(1853–61), last 10 years, and total 19 years. (3) Averages of 7 years (1855–'61), of 9 years (1853–'61), last 10 years, and total 19 years.

The produce of barley the first season (1852), was, per acre:

On the unmanured plot	27¼	bushels
With superphosphate of lime	28⅝	"
" potash, soda, and magnesia	26⅛	"
" " " " and superphosphate	32¾	"
" 14 tons barn-yard manure	33	"
" 200 lbs. ammonia-salts alone	36⅞	"
" " " and superphosphate	38⅝	"
" " " and potash, soda, and magnesia	36	"
" " " and superphosphate, potash, soda, and magnesia	40¾	"
" 400 lbs. ammonia-salts alone	44½	"

The 200 lbs. of ammonia-salts contain 50 lbs. of ammonia=41 lbs. nitrogen.

It will be seen that this 50 lbs. of ammonia alone, on plot 1*a*, gives an increase of nearly 10 bushels per acre, or to be more accurate, it gives an increase over the unmanured plot of 503 lbs. of grain, and 329 lbs. of straw, while double the quantity of ammonia on plot 1*a.a.*, gives an increase of 17¼ bushels per acre—or an increase of 901 lbs. of grain, and 1,144 lbs. of straw.

"Put that fact in separate lines, side by side," said the Deacon, "so that we can see it."

	Grain	*Straw*	*Total Produce.*
50 lbs. of ammonia gives an increase of	503 lbs.	704 lbs.	1207 lbs.
100 " " " " " " "	901 "	1144 "	2045 "
The first 50 lbs. of ammonia gives an increase of	503 "	704 "	1207 "
The second 50 lbs. of ammonia gives an increase of	398 "	540 "	738 "

"That shows," said the Deacon, "that a dressing of 50 lbs. per acre pays better than a dressing of 100 lbs. per acre. I wish Mr. Lawes had sown 75 lbs. on one plot."

I wish so, too, but it is quite probable that in our climate, 50 lbs. of available ammonia per acre is all that it will usually be profitable to apply per acre to the barley crop. It is equal to a dressing of 500 lbs. guaranteed Peruvian guano, or 275 lbs. nitrate of soda.—"Or to how much manure ?" asked the Deacon.

To about 5 tons of average stable-manure, or say three tons of good, well-rotted manure from grain-fed animals.

"And yet," said the Deacon, "Mr. Lawes put on 14 tons of yard manure per acre, and the yield of barley was not as much as from the 50 lbs. of ammonia alone. How do you account for that?"

Simply because the ammonia in the manure is *not* ammonia. It is what the chemists used to call "potential ammonia." A good deal of it is in the form of undigested straw and hay. The nitrogenous matter of the food which has been digested by the animal and thrown off in the liquid excrements, is in such a form that it will readily ferment and produce ammonia, while the nitrogenous matter in the undigested food and in the straw used for bedding, decomposes slowly even under the most favorable conditions; and if buried while fresh in a clay soil, it probably would not all decompose in many years. But we will not discuss this at present.

"The superphosphate does not seem to have done much good," said the Deacon; "3½ cwt. per acre gives an increase of less than two bushels per acre. And I suppose it was *good* superphosphate."

There need be no doubt on that point. Better superphosphate of lime cannot be made. But you must recollect that this is pure superphosphate made from burnt bones. It contains no ammonia or organic matter. Commercial superphosphates contain more or less ammonia, and had they been used in these experiments, they would have shown a better result than the pure article. They would have done good in proportion to the available nitrogen they contained. If these experiments prove anything, they clearly indicate that superphosphate alone is a very poor manure for either wheat or barley.

The *second* year, the unmanured plot gave 25¾ bushels per acre. Potash, soda, and magnesia, (or what the Deacon calls "ashes,") 27⅝ bushels; superphosphate 33½, and "ashes" and superphosphate, nearly 36 bushels per acre.

50 lbs. of ammonia, alone, gives nearly 39 bushels, and ammonia and superphosphate together, 40 bushels.

The superphosphate and "ashes" give a better account of themselves this year; but it is remarkable that the ammonia alone, gives almost as good a crop as the ammonia and superphosphate, and a *better* crop than the ammonia and "ashes," or the ammonia, superphosphate, and ashes, together.

The 14 tons farm-yard manure gives over 36 bushels per acre. This plot has now had 28 tons of manure per acre, yet the 50 lbs. of ammonia alone, still gives a better yield than this heavy dressing of manure.

The *third* season (1854), was quite favorable for the ripening of wheat and barley. The seed on the experimental barley-field, was sown Feb. 24, and the harvest was late; so that the crop had an unusually long season for growth. It was one of the years when even poor land, if clean, gives a good crop. The unmanured plot, it will be seen, yielded over 35 bushels per acre of dressed grain, weighing over 53½ lbs. per bushel. The total weight of grain, was 1,963 lbs. This is over 40 bushels per acre, of 48 lbs. per bushel, which is the standard with us.

11

The 14 tons of farm-yard manure produce nearly 56½ bushels per acre.

50 lbs. of ammonia, on plot 1*a*............47¾ bushels per acre.
100 " " " " " 1*a.a*..........56⅝ " "

You will see, that though the plot which has received 42 tons of manure per acre, produced a splendid crop; the plot having nothing except 100 lbs. of ammonia per acre, produced a crop equally good.

"How much increase do you get from 50 lbs. of ammonia," asked the Deacon, "and how much from 100 lbs.?"

	Grain.	*Straw.*	*Equal Amer. Bushels.*
50 lbs of ammonia, gives an increase of	800 lbs.	952 lbs.	16⅗ bush.
100 " " " " " "	" 1,350	" 2,100 "	28 "

If you buy nitrate of soda at 3¾ cents a lb., the ammonia will cost 20 cents a lb. In the above experiment, 50 lbs. of ammonia, costing $10, gives an increase of 16⅗ bushels of barley, and nearly half a ton of straw. If the straw is worth $4.00 per ton, the barley will cost 48 cents a bushel.

Double the quantity of manure, costing $20, gives an increase of 28 bushels of barley, and over one ton of straw. In this case the extra barley costs 57 cents a bushel.

On plot 2*a*., 50 lbs. of ammonia and 3½ cwt. of superphosphate, give 3,437 lbs. of grain, equal to 71½ of our bushels per acre.

On plot 2*a.a.* 100 lbs. of ammonia and 3½ cwt. of superphosphate, give 3,643 lbs. of grain, which lacks only 5 lbs. of 76 bushels per acre, and nearly 2½ tons of straw.

"That will do," said the Deacon, "but I see that in 1857, this same plot, with the same manure, produced 66½ bushels of dressed grain per acre, weighing 53½ lbs. to the bushel, or a total weight of 3,696 lbs., equal to just 77 of our bushels per acre."

"And yet," said the Doctor, "this same year, the plot which had 84 tons of farm-yard manure per acre, produced only 2,915 lbs. of grain, or less than 61 of our bushels of barley per acre."

The Squire happened in at this time, and heard the last remark. "What are you saying," he remarked, "about *only* 61 bushels of barley per acre. I should like to see such a crop. Last year, in this neighborhood, there were hundreds of acres of barley that did not yield 20 bushels per acre, and very little of it would weigh 44 lbs. to the bushel."

This is true. And the maltsters find it almost impossible to get six-rowed barley weighing 48 lbs. per bushel. They told me, that they would pay $1.10 per bushel for good bright barley weighing 48 lbs. per bushel, and for each pound it weighed less than this, they deducted 10 cents a bushel from the price. In other words, they would pay $1.00 a bushel for barley weighing 47 lbs. to the bushel; 90 cents for barley weighing 46 lbs; 80 cents for barley weighing 45 lbs., and 70 cents for barley weighing 44 lbs.—and at these figures they much preferred the heaviest barley.

It is certainly well worth our while, if we raise barley at all, to see if we cannot manage not only to raise larger crops per acre, but to produce barley of better quality. And these wonderful experiments of Mr. Lawes are well worth careful examination and study.

The Squire put on his spectacles and looked at the tables of figures.

"Like everybody else," said he, "you pick out the big figures, and to hear you talk, one would think you scientific gentlemen never have any poor crops, and yet I see that in 1860, there are three different crops of only 12⅛, 12¼, and 13¼ bushels per acre."

"Those," said I, "are the three plots which have grown barley every year without any manure, and you have selected the worst year of the whole twenty."

"Perhaps so," said the Squire, "but we have got to take the bad with the good, and I have often heard you say that a good farmer who has his land rich and clean makes more money in an unfavorable than in a favorable season. Now, this year 1860, seems to have been an unfavorable one, and yet your pet manure, superphosphate, only gives an *increase* of 148 lbs. of barley—or three bushels and 4 lbs. Yet this plot has had a tremendous dressing of 3½ cwt. of superphosphate yearly since 1852. I always told you you lost money in buying superphosphate."

"That depends on what you do with it. I use it for turnips, and tomatoes, cabbages, lettuce, melons, cucumbers, etc., and would not like to be without it; but I have never recommended any one to use it on wheat, barley, oats, Indian corn, or potatoes, except as an experiment. What I have recommended you to get for barley is, nitrate of soda, and superphosphate, or Peruvian guano. And you will see that even in this decidedly unfavorable season, the plot 2*a.a.*, dressed with superphosphate and 275 lbs. of nitrate of soda, produced 2,338 lbs. of barley, or 48¾ bushels per acre. This is an *increase* over the unmanured plots of 33½ bushels per acre, and an *increase* of 1,872 lbs. of straw. And the plot dressed with superphosphate and 200 lbs. of salts of ammonia, gave equally as good results."

And this, mark you, is the year which the Squire selected as the one most likely to show that artificial manures did not pay.

"I never knew a man except you," said the Squire, "who wanted unfavorable seasons."

I have never said I wanted unfavorable seasons. I should not dare to say so, or even to cherish the wish for one moment. But I do say, that when we have a season so favorable that even poorly worked land will produce a fair crop, we are almost certain to have prices below the average cost of production. But when we have an unfavorable season, such crops as barley, potatoes, and beans, often advance to extravagantly high prices, and the farmer who has good crops in such a season, gets something like adequate pay for his patient waiting, and for his efforts to improve his land.

"That sounds all very well," said the Squire," but will it pay to use these artificial manures?"

I do not wish to wander too much from the point, but would like to remark before I answer that question, that I am not a special advocate of artificial manures. I think we can often make manures on our farms far cheaper than we can buy them. But as the Squire has asked the question, and as he has selected from Mr. Lawes' results, the year 1860, I will meet him on his own ground. He has selected a season specially unfavorable for the growth of barley. Now, in such an unfavorable year in this country, barley would be likely to bring, at least, $1.25 per bushel, and in a favorable season not over 75 cents a bushel.

Mr. Lawes keeps his land *clean*, which is more than can be said of many barley-growers. And in this unfavorable season of 1860, he gets on his three unmanured plots an average of 730 lbs. of barley, equal to 15¼ bushels per acre, and not quite 800 lbs. of straw.

Many of our farmers frequently do no better than this. And you must recollect that in such careful experiments as those of Mr. Lawes and Dr. Gilbert, great pains would be taken to get all the barley that grew on the land. With us, barley is cut with a reaper, and admirable as our machines are, it is not an easy matter to cut a light, spindling crop of barley perfectly clean. Then, in pitching the crop and drawing it in, more or less barley is scattered, and even after we have been over the field two or three times with a steel-tooth rake, there is still considerable barley left on the ground. I think we may safely assume that at least as much barley is left on the ground as we usually sow—say two bushels per acre. And so, instead of having 15¼ bushels per acre, as Mr. Lawes had, we should only harvest 13¼ bushels.

Of all our ordinary farm crops, barley is attended with the least labor and expense. We usually sow it after corn or potatoes. On such strong land as that of Mr. Lawes, we ought to plow the land in the autumn and again in the spring, or at least stir up the land thoroughly with a two or three-horse cultivator or gang-plow.

Let us say that the cost of plowing, harrowing, drilling, and rolling, is $5.00 per acre. Seed, $2.00. Harvesting, $2.00. Threshing, 6 cents a bushel.

Receipts:

13¼ bushels barley @ 1.25..............		$16.57
800 lbs. of straw @ $4. per ton..........		1.60
		18.17
Putting in and harvesting the crop	$9.00	
Threshing 13¼ bushels @ 6 c......	.80	— 9.80
Rent and profit per acre...............		$ 8.37

"That is a better showing than I expected," said the Squire, "and as barley occupies the land only a few months, and as we sow wheat after it, we cannot expect large profits."

"Very well," said I, "Now let us take the crop, this same unfavorable year, on plot 2*a.a.*, dressed with superphosphate and nitrate of soda.

The expense of plowing, harrowing, drilling, rolling, seed, and harvesting, would be about the same, or we will say $2.00 an acre more for extra labor in harvesting. And we will allow two bushels per acre for scatterings—though there is nothing like as much barley left on the ground when we have a good crop, as when we have a poor crop. But I want to be liberal.

The yield on plot 2*a.a.*, was 48¾ bushels per acre, and 2,715 lbs. of straw.

Receipts:

46¾ bushels @ $1.25..........................		$58.43
2,715 lbs. straw @ $4. per ton................		5.43
		$63.86
Putting in the crop and harvesting...	$11.00	
Threshing 46¾ bushels @ 6 c..........	2.80	
275 lbs. nitrate of soda @ 4 c..........	11.00	
392 lbs. superphosphate @ 2 c........	7.84	
		$32.64
Rent and profit..		$31.22

In ordinary farm practice, I feel sure we can do better than this. Growing barley year after year on the same land, is not the most economical way of getting the full value of the manure. There is much nitrogen and phosphoric acid left in the land, which barley or even wheat does not seem capable of taking up, but which would probably be of great benefit to the clover.

MANURE AND ROTATION OF CROPS.

The old notion that there is any real chemical necessity for a rotation of crops is unfounded. Wheat can be grown after wheat, and barley after barley, and corn after corn, provided we use the necessary manures and get the soil clean and in the right mechanical condition.

"What, then, do we gain by a rotation?" asked the Deacon.

Much every way. A good rotation enables us to clean the land. We can put in different crops at different seasons.

"So we could," broke in the Deacon, "if we sowed wheat after wheat, barley after barley, and corn after corn."

True, but if we sowed winter-wheat after winter-wheat, there would not be time enough to clean the land.

"Just as much as when we sow wheat after oats, or peas, or barley."

"True again, Deacon," I replied, "but we are supposed to have cleaned the land while it was in corn the previous year. I say supposed, because in point of fact, many of our farmers do not half clean their land while it is in corn. It is the weak spot in our agriculture. If our land was as clean as it should be to start with, there is no rotation so convenient in this section, as corn the first year, barley, peas, or oats the second year, followed by winter-wheat seeded down. But to carry out this rotation to the best advantage we need artificial manures."

"But will they pay?" asks the Deacon.

"They will pay well, provided we can get them at a fair price and get fair prices for our produce. If we could get a good superphosphate made from Charleston phosphates for 1½ cent per lb., and nitrate of soda for 3½ or 4 cents per lb., and the German potash-salts for ¾ cent per lb., and could get on the average $1.25 per bushel for barley, and $1.75 for good white wheat, we could use these manures to great advantage."

"Nothing like barn-yard manure," says the Deacon.

No doubt on that point, provided it is good manure. Barn-yard manure, whether rich or poor, contains all the elements of plant-food, but there is a great difference between rich and poor manure. The rich manure contains twice or three times as much nitrogen and phosphoric acid as ordinary or poor manure. And this is the reason why artificial manures are valuable in proportion to the nitrogen and phosphoric acid that they contain in an available condition. When we use two or three hundred pounds per acre of a good artificial manure we in effect, directly or indirectly, convert poor manure into rich manure. There is manure in our soil, but it is poor. There is manure in our barn-yard, but it is poor also. Nitrogen and phosphoric acid will make these manures rich. This is the reason why a few pounds of a good artificial manure will produce as great an effect as tons of common manure. Depend upon it, the coming farmer will avail himself of the discoveries of science, and will use more artificial fertilizers.

But whether we use artificial fertilizers or farm-yard manure, we shall not get the full effect of the manures unless we adopt a judicious rotation of crops.

When we sow wheat after wheat, or barley after barley, or oats after oats, we certainly do not get the full effect of the manures used. Mr. Lawes' experiments afford conclusive evidence on this point. You will recollect that in 1846, one of the plots of wheat (10*b*), which had received a liberal dressing of salts of ammonia the year previous, was left without manure, and the yield of wheat on this plot was no greater than on the plot which was continuously unmanured. In other words, *the ammonia which was left in the soil from the previous year, had no effect on the wheat.*

The following table shows the amount of nitrogen furnished by the manure, and the amount recovered in the crop, when wheat is grown after wheat for a series of years, and also when barley is grown after barley, and oats after oats.

TABLE SHOWING THE AMOUNT OF NITROGEN RECOVERED, AND NOT RECOVERED, IN INCREASE OF PRODUCE, FOR 100 SUPPLIED IN MANURE.

Plots.	MANURES PER ACRE, PER ANNUM.	For 100 Nitrogen in Manure.	
		Recovered in Increase.	*Not Recovered in Increase.*
	WHEAT—20 YEARS, 1852–1871.		
6	Mixed Mineral Manure and 200 lbs. Ammonia-salts (= 41 lbs. Nitrogen)	32.4	67.6
7	Mixed Mineral Manure and 400 lbs. Ammonia-salts (= 82 lbs. Nitrogen)	32.9	67.1
8	Mixed Mineral Manure and 600 lbs. Ammonia-salts (= 123 lbs. Nitrogen)	31.5	68.5
16	Mixed Mineral Manure and 800 lbs. (1) Ammonia-salts (= 164 lbs. Nitrogen)	28.5	71.5
9 A	Mixed Mineral Manure and 550 lbs. (2) Nitrate Soda (= 82 lbs. Nitrogen)	45.3	54.7
2	14 tons Farmyard-Manure every year.	14.6	85.4
	BARLEY—20 YEARS, 1852–1871.		
4 A	Mixed Mineral Manure and 200 lbs. Ammonia-salts (= 41 lbs. Nitrogen)	48.1	51.9
4 AA	Mixed Mineral Manure and { 400 lbs. Ammonia-salts (= 82 lbs. Nitrogen) 6 years, 1852–'57; 200 lbs. Ammonia-salts (= 41 lbs. Nitrogen) 10 years, 1858–'67; 275 lbs. Nitrate Soda (= 41 lbs. Nitrogen) 4 years, 1868–'71 }	49.8	50.2
4 C	Mixed Mineral Manure and { 2000 lbs. Rape-cake (= 95 lbs. Nitrogen) 6 years, 1852–'57; 1000 lbs. Rape-cake (=47.5 lbs. Nitrogen) 14 years, 1858–'71 }	36.3	63.7
7	14 tons Farmyard-Manure every year.	10.7	89.3
	OATS—3 YEARS, 1869–1871.		
4	Mixed Mineral Manure and 400 lbs. Ammonia-salts (= 82 lbs. Nitrogen)	51.9	48.1
6	Mixed Mineral Manure and 550 lbs. Nitrate Soda (= 82 lbs. Nitrogen)	50.4	49.6

(1) 13 years only, 1852–1864. (2.) 475 lbs. Nitrate = 71 lbs. Nitrogen in 1852; 275 lbs. = 41 lbs. Nitrogen in 1853 and 1854; 550 lbs. = 82 lbs. Nitrogen each year afterwards.

It is not necessary to make any comments on this table. It speaks for itself; but it does not tell half the story. For instance, in the case of wheat and barley, it gives the average result for 20 years. It shows that when 100 lbs. of nitrogen in a soluble and available form, are applied to wheat, about 68 lbs. are *left in the soil.* But you must recollect that 100 lbs. was applied again the next year, and no account is taken of the 68 lbs. left in the soil—and so on for 20 years. In other words, on plot 8, for instance, 2,460 lbs. of nitrogen have been applied, and only 775 lbs. have been recovered in the total produce of grain, straw, and chaff, and 1,685 lbs. have been left in the soil.

Mr. Lawes estimates, from several analyses, that his farm-yard manure contains 0.637 per cent of nitrogen, 2.76 per cent of mineral matter, and 27.24 per cent of organic matter, and 70 per cent of water.

According to this, the plot dressed with 14 tons of manure every year, for 20 years, has received 3,995 lbs. of nitrogen, of which 583¼ lbs. were recovered in the produce, and 3,411¾ lbs. were left in the soil.

In the case of barley, 3,995 lbs. of nitrogen was applied during the 20 years to the plot dressed with farm-yard manure, of which 427½ lbs. were recovered in the crop, and 3,567½ lbs. left in the soil.

"I see," said the Deacon, "that barley gets less of the goodness out of farm-yard manure than wheat, but that it gets more out of the salts of ammonia and nitrate of soda. How do you account for that?"

"I suppose, because the manure for wheat was applied in the autumn, and the rains of winter and spring dissolved more of the plant-food than would be the case if the manure was applied in the spring. If the manure had been applied on the surface, instead of plowing it under, I believe the effect would have been still more in favor of the autumn-manuring."

When the nitrogen is in an available condition, spring barley can take up and utilize a larger proportion of the nitrogen than winter wheat. Neither the wheat nor the barley can get at and take up half what is applied, and this, notwithstanding the fact that a heavy dew or a slight rain furnishes water enough on an acre to dissolve a liberal dressing of nitrate of soda or sulphate and muriate of ammonia. The truth is, the soil is very conservative. It does not, fortunately for us, yield up all its plant-food in a year

We have seen that when wheat or barley is dressed with soluble ammonia-salts or nitrate of soda, a considerable amount of the nitrogen is left in the soil—and yet this nitrogen is of comparatively little benefit to the succeeding crops of wheat or barley, while a fresh dressing of ammonia-salts or nitrate of soda is of great benefit to the crop.

In other words, when wheat is sown after wheat, or barley after barley, we do not get half the benefit from the manure which it is theoretically capable of producing.

Now, the question is, whether by a judicious rotation of crops, we can avoid this great loss of manure ?

There was a time when it was thought that the growth of turnips enriched the soil. I have heard it said, again and again, that the reason English farmers grow larger crops of wheat and barley than we do, is because they grow so many acres of turnips.

"So I have often heard," said the Deacon, "and I supposed the broad turnip leaves absorbed nitrogen from the atmosphere."

There is no evidence that leaves have any such power; while there are many facts which point in an opposite direction. The following experiments of Lawes and Gilbert seem to show that the mere growth of turnips does not enrich land for grain crops.

Turnips were grown on the same land, year after year, for ten years. The land was then plowed and sown to barley for three years. The following table gives the results:

THREE YEARS OF BARLEY AFTER TEN YEARS OF TURNIPS.

PARTICULARS OF MANURES, ETC.	*Produce of Barley per Acre.*			
	1853.	1854.	1855.	*Average 3 Years.*
	bush.	bush.	bush.	bush.
Hoos-Field—				
Barley, without manure, after 3 corn-crops.........	26	35⅛	34⅛	31⅜
Barn-Field—				
Barley, after 10 yrs. Turnips manured as under—				
1.—Mineral manures (last 8 years)......	20½	19⅜	20	20
2.—Mineral manures (8 yrs.); Ammonia-salts (6 yrs.).	23⅛	21¼	21¾	22
3.—Mineral manures (8 yrs.); Rape-cake (6 yrs.)......	28¾	24⅝	23⅛	25¾
4.—Mineral manures (8 yrs.); Ammonia-salts and Rape-cake (6 yrs.)	29⅛	23¾	23¾	25⅝
5.—Mineral manures (8 yrs.); Ammonia-salts, for Barley, 1854.....	(20½)	52⅜	26⅝	39½
6.—Mineral manures (8 yrs.); Nitrate Soda, for Barley, '54 and '55..............................	(20½)	54⅞	40⅜	47⅝

The yield of barley after turnips is less than it is after grain crops, and it is evident that this is due to a lack of available nitrogen in the soil. In other words, the turnips leave *less* available nitrogen in the soil than grain crops.

After alluding to the facts given in the foregoing table, Messrs. Lawes and Gilbert say:

"There is evidence of another kind that may be cited as showing that it was of available nitrogen that the turnips had rendered the soil so deficient for the after-growth of barley. It may be assumed that, on the average, between 25 and 30 lbs. of nitrogen would be annually removed from the Rothamsted soil by wheat or barley grown year after year without nitrogenous manure. But it is estimated that from the mineral-manured turnip-plots there were, over the 10 years, more than 50 lbs. of nitrogen per acre per annum removed. As, however, on some of the plots, small quantities of ammonia-salts or rape-cake were applied in the first two years of the ten of turnips, it is, perhaps, more to the purpose to take the average over the last 8 years of turnips only; and this would show about 45 lbs. of nitrogen removed per acre per annum. An immaterial proportion of this might be due to the small amounts of nitrogenous manures applied in the first two years. Still, it may be assumed that about 1½ time as much nitrogen was removed from the land for 8, if not for 10 years, in succession, as would have been taken in an equal number of crops of wheat or barley grown without nitrogenous manure. No wonder, then, that considerably less barley has been grown in 3 years after a series of mineral-manured turnip-crops, than was obtained in another field after a less number of corn-crops.

"The results obtained in Barn-field afford a striking illustration of the dependence of the turnip-plant on a supply of available nitrogen within the soil, and of its comparatively great power of exhausting it. They are also perfectly consistent with those in Hoos-field, in showing that mineral manures will not yield fair crops of barley, unless there be, within the soil, a liberal supply of available nitrogen. The results obtained under such very different conditions in the two fields are, in fact, strikingly mutually confirmatory."

CHAPTER XXX.

MANURES FOR OATS.

"What is the use of talking about manure for oats," said the Deacon, "if land is not rich enough to produce oats without manure, it certainly will not pay to manure them. We can use our manure on some crop that will pay better."

"That is precisely what we want to know," said I. "Very likely you are right, but have you any evidence?"

"Evidence of what?"

"Have you any facts that show, for instance, that it will pay better to use manure for wheat or barley than for oats?"

"Can't say that I have, but I think manure will pay better on wheat than on oats."

Mr. Lawes is making a series of experiments on oats. Let us take a hasty glance at the results of the first two seasons:

EXPERIMENTS ON OATS AT ROTHAMSTED.

MANURES PER ACRE.	*Grain, in bushels.*		*Straw, cwts.*		*Weight per bushel, lbs.*	
	1869.	1870.	1869.	1870.	1869.	1870.
1.—No manure	36⅝	16⅜	19¼	9⅛	36¾	35
2.—Mixed Alkalies and Superphosphate of Lime	45	19⅛	24½	9⅝	38½	35⅛
3.—400 lbs. Ammonia-salts	56⅛	37½	36⅞	17¼	37½	34¼
4.—Mixed Alkalies and Superphosphate, and 400 lbs. Ammonia-salts	75¼	50⅝	54	28⅝	39¼	36
5.—550 lbs. Nitrate of Soda	62¼	36½	42¾	23	38½	35¼
6.—Mixed Alkalies, Superphosphate, and 550 lbs. Nitrate of Soda	69⅜	50	49⅞	28¾	38½	35¾

It seems clear that, for oats, as for barley and wheat, what we most need in manure, is available nitrogen.

The first year, the no-manure plot produced 36⅝ bushels of oats per acre, weighing 36¾ lbs. per bushel, and plot 3, with ammonia-salts alone, 56⅛ bushels, and with nitrate of soda alone, on plot 5, 62¼ bushels per acre, both weighing 38½ lbs. per bushel. In other words, 82 lbs. of available nitrogen in the salts of ammonia gave an increase of about 20 bushels per acre, and the same quantity of nitrogen in nitrate of soda an increase of 26 bushels per acre.

The next year, the season seems to have been a very unfavorable one for oats. The no-manure plot produced less than 17 bushels per acre; and the "ashes" and superphosphate on plot 2, give an increase of less than 3 bushels per acre. But it will be seen that on plot 3 the ammonia-salts do as much good in this unfavorable season as in the favorable one. They give an increase of over 20 bushels per acre.

"A few such facts as this," said the Deacon, "would almost persuade me that you are right in contending that it is in the unfavorable seasons, when prices are sure to be high in this country, that a good farmer stands the best chance to make money."

"Where mixed alkalies and superphosphate," said the Doctor, "are added to the ammonia, the increase *from the ammonia* is far greater than where ammonia is used alone. In other words, by comparing plot 2 and plot 4, you will see that the ammonia gives an increase of 30¼ bushels per acre in 1869, and 31½ bushels in 1870."

The truth of the matter probably is this: 100 lbs. of available ammonia per acre is an excessive supply, when used alone. And in fact Mr. Lawes himself only recommends about half this quantity.

Whether it will pay us to use artificial manures on oats depends on the price we are likely to get for the oats. When the price of oats *per lb.* and oat-straw is as high as barley and barley-straw *per lb.*, then it will pay a *little better* to use manure on oats than on barley. As a rule in this country, however, good barley is worth more per lb. than good oats; and it will usually pay better to use artificial manures on barley than on oats.

Some years ago Mr. Bath, of Virginia, made some experiments on oats with the following results:

	Bushels of oats per acre.
No. 1—200 lbs. Superphosphate	22
No. 2—200 lbs. Peruvian guano	48¾
No. 3—100 lbs. Peruvian guano	32

The oats were sown March 13, and the crop harvested July 4.

In 1860, I made some experiments with gypsum, superphosphate, and sulphate of ammonia as a top-dressing on oats.

The land was a clover-sod, plowed about the middle of May, and the oats sown May 20. On the 26th of May, just as the oats were coming up, the manures were sown broadcast. The oats were sown too late to obtain the best results. On another field, where the oats were sown two weeks earlier, the crop was decidedly better. The oats were cut August 28.

The following is the result:

EXPERIMENTS ON OATS AT MORETON FARM, ROCHESTER, N. Y.

Plots.	MANURES PER ACRE.	*Bushels of Oats per acre.*	*Weight per Bushel in lbs.*	*Straw per acre in lbs.*
No. 1	No manure..............................	36	22	1,958
2	600 lbs. Gypsum (Sulphate of Lime).....	47	26	2,475
3	300 lbs. Superphosphate of Lime.......	50	21	2,475
4	300 lbs. Sulphate of Ammonia............	50	22	2,750
5	300 lbs. Superphosphate of Lime, and 300 lbs. Sulphate of Ammonia...............	51	22½	2,575

These experiments were made when my land was not as clean as it is now. I presume the weeds got more benefit from the ammonia than the oats. To top-dress foul land with expensive artificial manures is money thrown away. If the land had been plowed in the autumn, and the seed and manures could have been put in early in the spring, I presume we should have had more favorable results.

"Are you not ashamed to acknowledge," said the Deacon, "that you have ever raised oats weighing only 22 lbs. per bushel."

No. I have raised even worse crops than this—and so has the Deacon. But I made up my mind that such farming did not pay, and I have been trying hard since then to clean my land and get it into better condition. And until this is done, it is useless to talk much of artificial manures.

The most striking result is the effect of the gypsum. It not only gave an increased yield of 11 bushels per acre, but the oats were of decidedly better quality, and there was nearly half a ton more straw per acre than on the plot alongside, where no manure was used.

The superphosphate was a good article, similar to that used in Mr. Lawes' experiments.

CHAPTER XXXI.

MANURES FOR POTATOES.

Some time ago, a farmer in Pennsylvania wrote me that he wanted "to raise a first-rate crop of potatoes." I answered him as follows through the *American Agriculturist:*

"There are many ways of doing this. But as you only enter on the farm this spring, you will work to disadvantage. To obtain the best results, it is necessary to prepare for the crop two or three years beforehand. All that you can do this year is to select the best land on the farm, put on 400 lbs. of Peruvian guano, cultivate thoroughly, and suffer not a weed to grow. A two or three-year-old clover-sod, on warm, rich, sandy loam, gives a good chance for potatoes. Do not plow until you are ready to plant. Sow the guano broadcast after plowing, and harrow it in, or apply a tablespoonful in each hill, and mix it with the soil. Mark out the rows, both ways, three feet apart, and drop a fair-sized potato in each hill. Start the cultivator as soon as the rows can be distinguished, and repeat every week or ten days until there is danger of disturbing the roots. We usually hill up a little, making a broad, flat hill. A tablespoonful of plaster, dusted on the young plants soon after they come up, will usually do good. We recommend guano, because in our experience it does not increase the rot. But it is only fair to add, that we have not found even barn-yard manure, if thoroughly rotted and well mixed with the soil the fall previous, half so injurious as some people would have us suppose. If any one will put 25 loads per acre on our potato land, we will agree to plant and run the risk of the rot. But we would use some guano as well. The truth is, that it is useless to expect a large crop of potatoes, say 350 bushels per acre, without plenty of manure."

This was written before the potato-beetle made its appearance. But I think I should say the same thing now—only put it a little stronger. The truth is, it will not pay to "fight the bugs" on a poor crop of potatoes. We must select the best land we have and make it as rich as possible.

"But why do you recommend Peruvian guano," asked the Doctor, "rather than superphosphate or ashes? Potatoes contain a large amount of potash, and one would expect considerable benefit from an application of ashes."

"Ashes, plaster, and hen-dung," said the Judge, "will at any rate pay well on potatoes. I have tried this mixture again and again, and always with good effect."

"I believe in the hen-dung," said I, "and possibly in the plaster, but on my land, ashes do not seem to be specially beneficial on potatoes, while I have rarely used Peruvian guano without good effect; and sometimes it has proved wonderfully profitable, owing to the high price of potatoes."

Sometime ago, I had a visit from one of the most enterprising and successful farmers in Western New York.

"What I want to learn," he said, "is how to make manure enough to keep my land in good condition. I sell nothing but beans, potatoes, wheat, and apples. I feed out all my corn, oats, stalks, straw, and hay on the farm, and draw into the barn-yard the potato-vines and everything else that will rot into manure. I make a big pile of it. But the point with me is to find out what is the best stock to feed this straw, stalks, hay, oats, and corn to, so as to make the best manure and return the largest profit. Last year I bought a lot of steers to feed in winter, and lost money. This fall I bought 68 head of cows to winter, intending to sell them in the spring."

"What did they cost you?"

"I went into Wyoming and Cattaraugus Counties, and picked them up among the dairy farmers, and selected a very fair lot of cows at an average of $22 per head. I expect to sell them as new milch cows in the spring. Such cows last spring would have been worth $60 to $70 each."

"That will pay. But it is not often the grain-grower gets such a chance to feed out his straw, stalks, and other fodder to advantage. It cannot be adopted as a permanent system. It is bad for the dairyman, and no real help to the grain-grower. The manure is not rich enough. Straw and stalks alone can not be fed to advantage. And when you winter cows to sell again in the spring, it will not pay to feed grain. If you were going to keep the cows it would pay well. The fat and flesh you put on in the winter would be returned in the form of butter and cheese next summer."

"Why is not the manure good? I am careful to save everything, and expect seven or eight hundred loads of manure in the spring."

"You had 60 acres of wheat that yielded 25 bushels per acre, and have probably about 50 tons of wheat straw. You had also 30 acres oats, that yielded 50 bushels per acre, say 35 tons of straw. Your 20 acres of corn produced 40 bushels of shelled corn per acre; say the stalks weigh 30 tons. And you have 60 tons of hay, half clover and half timothy. Let us see what your manure from this amount of grain and fodder is worth.

Manures from		
	50 tons wheat-straw, @ $2.68	$ 134.00
	35 tons oat-straw, @ $2.90	101.50
	30 tons corn-stalks, @ $3.58	107.40
	30 tons timothy-hay, @ $6.43	192.90
	30 tons clover-hay, @ $9.64	289.20
	14 tons oats (1,500 bush.), @ $7.70	107.80
	24 tons corn (800 bushels), @ $6.65	159.60
Total	213 tons	$1,092.40

"This is the value of the manure *on the land.* Assuming that there are 600 loads, and that the labor of cleaning out the stables, piling, carting, and spreading the manure is worth 30 cents per load, or $180, we have $912.40 as the net value of the manure.

"Now, your 250-acre farm *might* be so managed that this amount of manure annually applied would soon greatly increase its fertility. But you do not think you can afford to summer-fallow, and you want to raise thirty or forty acres of potatoes every year."

"I propose to do so," he replied. "Situated as I am, close to a good shipping station, no crop pays me better. My potatoes this year have averaged me over $100 per acre."

"Very good. But it is perfectly clear to my mind that sooner or later, you must either farm slower or feed higher. And in your case, situated close to a village where you can get plenty of help, and with a good shipping station near by, you had better adopt the latter plan. You must feed higher, and make richer manure. You now feed out 213 tons of stuff, and make 600 loads of manure, worth $912.40. By feeding out *one third*, or 71 tons more, you can *more than double* the value of the manure.

50 tons of bran or mill-feed would give manure worth	$ 729.50
21 tons decorticated cotton-seed cake	585.06
	$1,314.56

"Buy and feed out this amount of bran and cake, and you would have 800 loads of manure, worth *on the land* $2,226.96, or, estimating as before that it cost 30 cents a load to handle it, its net value would be $1,986.96."

I am well aware that comparatively few farmers in this section can afford to adopt this plan of enriching their land. We want better stock. I do not know where I could buy a lot of steers that it would pay to fatten in the winter. Those farmers who raise good grade Shorthorn or Devon cattle are not the men to sell them half-fat at low rates. They can fatten them as well as I can. For some time to come, the farmer who proposes to feed liberally, will have to raise his own stock. He can rarely buy well-bred animals to fatten. A good farmer must be a good farmer throughout. He can not be good in spots. His land must be drained, well-worked, and free from weeds. If he crops heavily he must manure heavily, and to do this he must feed liberally—and he can not afford to feed liberally unless he has good stock.

"I have, myself, no doubt but you are right on this point," said the Doctor, "but all this *takes time.* Suppose a farmer becomes satisfied that the manure he makes is not rich enough. To tell him, when he is anxious to raise a good crop of potatoes next year, that he must go to work and improve his stock of cattle, sheep, and swine, and then buy bran and oil-cake to make richer manure, is somewhat tantalizing."

This is true, and in such a case, instead of adding nitrogen and phosphoric acid to his manure in the shape of bran, oil-cake, etc., he can buy nitrogen and phosphoric acid in guano or in nitrate of soda and superphosphate. This gives him richer manure; which is precisely what he wants for his potatoes. His poor manure is not so much deficient in potash as in nitrogen and phosphoric acid, and consequently it is nitrogen and phosphoric acid that he will probably need to make his soil capable of producing a large crop of potatoes.

I have seen Peruvian guano extensively used on potatoes, and almost always with good effect. My first experience with it in this country, was in 1852. Four acres of potatoes were planted on a two-year-old clover-sod, plowed in the spring. On two acres, Peruvian guano was sown broadcast at the rate of 300 lbs. per acre and harrowed in. The potatoes were planted May 10. On the other two acres no manure of any kind was used, though treated exactly alike in every other respect. The result was as follows:

No manure	119 bushels per acre.
300 lbs. Peruvian guano	205 " "

The guano cost, here, about 3 cents a lb., and consequently nine dollars' worth of guano gave 84 bushels of potatoes. The potatoes were all sound and good, but where the guano was used, they were larger, with scarcely a small one amongst them.

In 1857, I made the following experiments on potatoes, in the same field on which the preceding experiment was made in 1852.

In this case, as before, the land was a two-year-old clover-sod. It was plowed about the first of May, and harrowed until it was in a good mellow condition. The potatoes were planted in hills 3½ feet apart each way. The following table shows the manures used and the yield of potatoes per acre.

EXPERIMENTS ON POTATOES AT MORETON FARM.

Number of Plot.	DESCRIPTION OF MANURES USED, AND QUANTITIES APPLIED PER ACRE.	*Yield of Potatoes per acre, in bushels.*	*Increase of Potatoes per acre, in bushels, caused by manure.*
1.	No manure.	95	
2.	150 lbs. sulphate of ammonia	140	45
3.	300 lbs. superphosphate of lime	132	37
4.	150 lbs. sulphate of ammonia, and 300 lbs. superphosphate of lime	179	84
5.	400 lbs. of unleached wood-ashes	100	5
6.	100 lbs. plaster, (gypsum, or sulphate of lime,)	101	6
7.	400 lbs. unleached wood-ashes and 100 lbs. plaster	110	15
8.	400 lbs. unleached wood-ashes, 150 lbs. sulphate of ammonia, and 100 lbs. plaster	109	14
9.	300 lbs. superphosphate of lime, 150 lbs. sulphate of ammonia and 400 lbs. unleached wood-ashes	138	43

The superphosphate of lime was made expressly for experimental purposes, from calcined bones, ground fine, and mixed with sulphuric acid in the proper proportions to convert all the phosphate of lime of the bones into the soluble superphosphate. It was a purely mineral article, free from ammonia and other organic matter. It cost about two and a half cents per pound.

The manures were deposited in the hill, covered with an inch or two of soil, and the seed then planted on the top. Where superphosphate of lime or sulphate of ammonia was used in conjunction with ashes, the ashes were first deposited in the hill and covered with a little soil, and then the superphosphate or sulphate of ammonia placed on the top and covered with soil before the seed was planted. Notwithstanding this precaution, the rain washed the sulphate of ammonia into the ashes, and decomposition, with loss of ammonia, was the result. This will account for the less yield on plot 8 than on plot 2. It would have been better to have sown the ashes broadcast, but some previous experiments with Peruvian guano on potatoes indicated that it was best to apply guano in the hill, carefully covering it with soil to prevent it injuring the seed, than to sow it broadcast. It was for this reason, and for the greater convenience in sowing, that the manures were applied in the hill.

The ash of potatoes consists of about 50 per cent of potash, and this fact has induced many writers to recommend ashes as a manure for this crop. It will be seen, however, that in this instance, at least, they have very little effect, 400 lbs. giving an increase of only five bushels per acre. One hundred pounds of plaster per acre gave an increase of six bushels. Plaster and ashes combined, an increase per acre of 15 bushels.

One fact is clearly brought out by these experiments: that this soil, which has been under cultivation without manure for many years, is not, relatively to other constituents of crops, deficient in potash. Had such been the case, the sulphate of ammonia and superphosphate of lime—manures which contain no potash—would not have given an increase of 84 bushels of potatoes per acre. There was sufficient potash in the soil, in an available condition, for 179 bushels of potatoes per acre; and the reason why the soil without manure produced only 95 bushels per acre, was owing to a deficiency of ammonia and phosphates.

Since these experiments were made, Dr. Vœlcker and others have made similar ones in England. The results on the whole all point in one direction. They show that the manures most valuable for potatoes are those rich in nitrogen and phosphoric acid, and that occasionally potash is also a useful addition.

"There is one thing I should like to know," said the Doctor. "Admitting that nitrogen and phosphoric acid and potash are the most important elements of plant-food, how many bushels of potatoes should we be likely to get from a judicious application of these manures?"

"There is no way," said I, "of getting at this with any degree of certainty. The numerous experiments that have been made in England seem to show that a given quantity of manure will produce a larger *increase* on poor land than on land in better condition."

In England potatoes are rarely if ever planted without manure, and the land selected for this crop, even without manure, would usually be in better condition than the average potato land of this section, and consequently a given amount of manure, applied to potatoes here, would be likely to do more good, up to a certain point, than the same amount would in England.

Let us look at some of the experiments that have been made in England:—

In the Transactions of the Highland and Agricultural Society of Scotland for 1873 is a prize essay on "Experiments upon Potatoes, with Potash Salts, on Light Land," by Charles D. Hunter, F. C. S., made on the farm of William Lawson, in Cumberland. Mr. Hunter "was charged with the manuring of the farm and the purchasing of chemical manures to the annual value of £2,000," or say $10,000.

"Potatoes," says Mr. Hunter, "were largely grown on the farm, and in the absence of a sufficiency of farm-yard manure, potash naturally suggested itself as a necessary constituent of a chemical potato-manure. The soil was light and gravelly, with an open subsoil, and the rainfall from 29 to 38 inches a year."

The first series of experiments was made in 1867. The following are some of the results :—

	Bushels per acre.
No manure	221
4 cwt. mineral superphosphate	225
4 cwt. mineral superphosphate and 4 cwt. of muriate of potash	240
15½ tons farm-yard manure	293

"That does not say much for potash and superphosphate," said the Deacon. "The superphosphate only produced four bushels more than the no manure, and the potash and superphosphate only fifteen bushels more than the superphosphate alone."

It may be worth while mentioning that one of the experimental plots this year was on a head-land, "where the cattle frequently stand for shelter." This plot was dressed with only eight and a half tons of manure, and the crop was over 427 bushels per acre, while a plot alongside, without manure, produced only 163 bushels per acre.

"That shows the importance," said the Deacon, "of planting potatoes on rich land, rather than to plant on poor land and try to make it rich by applying manure directly to the crop."

The following are some of the results in 1868 :

		Bushels per acre.
1.	No manure	232
2.	4 cwt. superphosphate 2 " muriate of potash 2 " sulphate of ammonia	340
3.	20 tons farm-yard manure	342
4.	4 cwt. superphosphate 4 " muriate of potash	274

"Here again," said the Doctor, "superphosphate and potash alone give an increase of only forty-two bushels per acre, while on plot 2, where two hundred weight of muriate of potash is substituted by two hundred weight of sulphate of ammonia, the increase is 108 bushels per acre. It certainly looks as though a manure for potatoes, so far as yield is concerned, should be rich in available nitrogen."

The following are some of the results in 1869:

		Bushels per acre.
1.	No manure	176
2.	4 cwt. superphosphate ¾ " sulphate of magnesia 2 " muriate of potash 2 " sulphate of ammonia	306
3.	4 cwt. superphosphate	189
4.	4 cwt. superphosphate 2 " sulphate of ammonia	201
5.	4 cwt. superphosphate 2 " muriate of potash 2 " sulphate of ammonia	340
6.	4 cwt. superphosphate 2 " muriate of potash	249

"This is a very interesting experiment," said the Doctor. "Superphosphate alone gives an increase of thirteen bushels. Superphosphate and potash an increase of seventy-three bushels. The potash, therefore, gives an increase of sixty bushels. Superphosphate *and* ammonia give twelve bushels more than superphosphate alone, and the reason it does not produce a better crop is owing to a deficiency of potash. When this is supplied the ammonia gives an increase (plots 5 and 6) of ninety-one bushels per acre."

In 1870 the above experiments were repeated on the same land, with the same general results.

In 1871 some experiments were made on a sharp, gravelly soil, which had been over-cropped, and was in poor condition. The following are the results:—

		Bushels per acre.
1.	9 cwt. superphosphate 3 " sulphate of ammonia	186
2.	9 cwt. superphosphate 3½ " muriate of potash 3 " sulphate of ammonia	204
3.	No manure	70
4.	9 cwt. superphosphate 3½ " muriate of potash 3 " sulphate of ammonia	205
5.	20 tons farm-yard manure	197

"On this poor soil," said the Doctor, "the ammonia and superphosphate gave an increase of 116 bushels per acre; and 3½ hundred weight of muriate of potash an increase, on one plot, of eighteen bushels, and on the other nineteen bushels per acre."

In the same year, 1871, another set of experiments was made on a better and more loamy soil, which had been in grass for several years. In 1869 it was sown for hay, and in 1870 was broken up and sown to oats, and the next spring planted with potatoes. The following are some of the results:

		Bushels per acre.
1.	6¼ cwt. superphosphate; 2½ " muriate of potash; 2½ " sulphate of ammonia	321
2.	6¼ cwt. superphosphate; 2½ " sulphate of ammonia	296
3.	No manure	252
4.	6¼ cwt. superphosphate; 2½ " muriate of potash	311
5.	2½ cwt. sulphate of ammonia	238
6.	15 tons farm-yard manure	365

"It is curious," said the Doctor, "that the plot with sulphate of ammonia alone should produce less than the no-manure plot."

"The sulphate of ammonia," said I, "may have injured the seed, or it may have produced too luxuriant a growth of vine."

Another series of experiments was made on another portion of the same field in 1871. The "no-manure" plot produced 337 bushels per acre. Manures of various kinds were used, but the largest yield, 351 bushels per acre, was from superphosphate and sulphate of ammonia; fourteen tons barn-yard manure produce 340 bushels per acre; and Mr. Hunter remarks: "It is evident that, when the produce of the unmanured soil reaches nine tons [336 bushels] per acre, there is but little scope for manure of any kind."

"I do not see," said the Doctor, "that you have answered my question, but I suppose that, with potatoes at fifty cents a bushel, and wheat at $1.50 per bushel, artificial manures can be more profitably used on potatoes than on wheat, and the same is probably true of oats, barley, corn, etc."

I have long been of the opinion that artificial manures can be applied to potatoes with more profit than to any other ordinary farm-crop, for the simple reason that, in this country, potatoes, on the average, command relatively high prices.

For instance, if average land, without manure, will produce fifteen bushels of wheat per acre and 100 bushels of potatoes, and a given quantity of manure costing, say $25, will double the crop, we have, in the one case, *an increase* of:—

15 bushels of wheat at $1.50	$22.50
15 cwt. of straw	3.50
	$26.00
Cost of manure	25.00
Profit from using manure	$1.00

And in the other:—

100 bushels of potatoes at 50 cents	$50.00
Cost of manure	25.00
Profit from using manure	$25.00

The only question is, whether the same quantity of the right kind of manure is as likely to double the potato crop as to double the wheat crop, when both are raised on average land.

"It is not an easy matter," said the Deacon, "to double the yield of potatoes."

"Neither is it," said I, "to double the yield of wheat, but both can be done, provided you start low enough. If your land is clean, and well worked, and dry, and only produces ten bushels of wheat per acre, there is no difficulty in making it produce twenty bushels; and so of potatoes. If the land be dry and well cultivated, and, barring the bugs, produces without manure 75 bushels per acre, there ought to be no difficulty in making it produce 150 bushels.

"But if your land produces, without manure, 150 bushels, it is not always easy to make it produce 300 bushels. Fortunately, or unfortunately, our land is, in most cases, poor enough to start with, and we ought to be able to use manure on potatoes to great advantage."

"But will not the manure," asked the Deacon," injure the quality of the potatoes?"

I think not. So far as my experiments and experience go, the judicious use of good manure, on dry land, favors the perfect maturity of the tubers and the formation of starch. I never manured potatoes so highly as I did last year (1877), and never had potatoes of such high quality. They cook white, dry, and mealy. We made furrows two and a half feet apart, and spread rich, well-rotted manure in the furrows, and planted the potatoes on top of the manure, and covered them with a plow. In our climate, I am inclined to think, it would be better to apply the manure to the land for potatoes the autumn previous. If sod land, spread the manure on the surface, and let it lie exposed all winter. If stubble land, plow it in the fall, and then spread the manure in the fall or winter, and plow it under in the spring.

CHAPTER XXXII.

WHAT CROPS SHOULD MANURE BE APPLIED TO.

"It will not do any harm on any crop," said the Deacon, "but on my farm it seems to be most convenient to draw it out in the winter or spring, and plow it under for corn. I do not know any farmer except you who uses it on potatoes."

My own rule is to apply manure to those crops which require the most labor per acre. But I am well aware that this rule will have many exceptions. For instance, it will often pay well to use manure on barley, and yet barley requires far less labor than corn or potatoes.

People who let out, and those who work farms "on shares" seldom understand this matter clearly. I knew a farmer, who last year let out a field of good land, that had been in corn the previous year, to a man to sow to barley, and afterwards to wheat on "the halves." Another part of the farm was taken by a man to plant corn and potatoes on similar terms, and another man put in several acres of cabbage, beets, carrots, and onions on halves. It never seemed to occur to either of them that the conditions were unequal. The expense of digging and harvesting the potato-crop alone was greater than the whole cost of the barley-crop; while, after the barley was off, the land was plowed once, harrowed, and sowed to winter wheat; and nothing more has to be done to it until the next harvest. With the garden crops, the difference is even still more striking. The labor expended on one acre of onions or carrots would put in and harvest a ten-acre field of barley. If the tenant gets pay for his labor, the landlord would get say $5 an acre for his barley land, and $50 for his carrot and onion land. I am pretty sure the tenants did not see the matter in this light, nor the farmer either.

Crops which require a large amount of labor can only be grown on very rich land. Our successful market-gardeners, seed-growers, and nurserymen understand this matter. They must get great crops or they cannot pay their labor bill. And the principle is applicable to ordinary farm crops. Some of them require much more labor than others, and should never be grown unless the land is capable of producing a maximum yield per acre, or a close approximation to it. As a rule, the least-paying crops are those which require the least labor per acre. Farmers are afraid to expend much money for labor. They are wise in this, unless all the conditions are favorable. But when they have land in a high state of cultivation—drained, clean, mellow, and rich—it would usually pay them well to grow crops which require the most labor.

And it should never be forgotten that, as compared with nearly all other countries, our labor is expensive. No matter how cheap our land may be, we can not afford to waste our labor. It is too costly. If men would work for nothing, and board themselves, there are localities where we could perhaps afford to keep sheep that shear two pounds of wool a year; or cows that make 75 lbs. of butter. We might make a profit out of a wheat-crop of 8 bushels per acre, or a corn-crop of 15 bushels, or a potato-crop of 50 bushels. But it cannot be done with labor costing from $1.00 to $1.25 per day. And I do not believe labor will cost much less in our time. The only thing we can do is to employ it to the best advantage. Machinery will help us to some extent, but I can see no real escape from our difficulties in this matter, except to raise larger crops per acre.

In ordinary farming, "larger crops per acre" means fewer acres planted or sown with grain. It means more summer fallow, more grass, clover, peas, mustard, coleseed, roots, and other crops that are consumed on the farm. It means more thorough cultivation. It means clean and rich land. It means husbanding the ammonia and nitric acid, which is brought to the soil, as well as that which is developed from the soil, or which the soil attracts from the atmosphere, and using it to grow a crop every second, third, or fourth year, instead of every year. If a piece of land will grow 25 bushels of corn every year, we should aim to so manage it, that it will grow 50 every other year, or 75 every third year, or, if the *climate* is capable of doing it, of raising 100 bushels per acre every fourth year.

Theoretically this can be done, and in one of Mr. Lawes' experiments he did it practically in the case of a summer-fallow for wheat, the one crop in two years giving a little more than two crops sown in succession. But on sandy land we should probably lose a portion of the liberated plant-food, unless we grew a crop of some kind every year. And the matter organized in the renovating crop could not be rendered completely available for the next crop. *In the end*, however, we ought to be able to get it with little or no loss. How best to accomplish this result, is one of the most interesting and important fields for scientific investigation and practical experiment. We know enough, however, to be sure that there is a great advantage in waiting until there is a sufficient accumulation of available plant-food in the soil to produce a large yield, before sowing a crop that requires much labor.

If we do not want to wait, we must apply manure. If we have no barn-yard or stable-manure, we must buy artificials.

HOW AND WHEN MANURE SHOULD BE APPLIED.

This is not a merely theoretical or chemical question. We must take into consideration the *cost* of application. Also, whether we apply it at a busy or a leisure season. I have seen it recommended, for instance, to spread manure on meadow-land immediately after the hay-crop was removed. Now, I think this may be theoretically very good advice. But, on my farm, it would throw the work right into the midst of wheat and barley harvests; and I should make the theory bend a little to my convenience. The meadows would have to wait until we had got in the crops—or until harvest operations were stopped by rain.

I mention this merely to show the complex character of this question. On my own farm, the most leisure season of the year, except the winter, is immediately after wheat harvest. And, as already stated, it is at this time that John Johnston draws out his manure and spreads it on grass-land intended to be plowed up the following spring for corn.

If the manure was free from weed-seeds, many of our best farmers, if they had some well-rotted manure like this of John Johnston's, would draw it out and spread it on their fields prepared for winter-wheat.

In this case, I should draw out the manure in heaps and then spread it carefully. Then harrow it, and if the harrow pulls the manure into heaps, spread them and harrow again. It is of the greatest importance to spread manure evenly and mix it thoroughly with the soil. If this work is well done, and the manure is well-rotted, it will not interfere with the drill. And the manure will be near the surface, where the young roots of the wheat can get hold of it.

"You must recollect," said the Doctor, "that the roots can only take up the manure when in solution."

"It must also be remembered," said I, "that a light rain of, say, only half an inch, pours down on to the manures spread on an acre of land about 14,000 gallons of water, or about 56 tons. If you have put on 8 tons of manure, half an inch of rain would furnish a gallon of water to each pound of manure. It is not difficult to understand, therefore, how manure applied on the surface, or near the surface, can be taken up by the young roots."

"That puts the matter in a new light to me," said the Deacon. "If the manure was plowed under, five or six inches deep, it would require an abundant rain to reach the manure. And it is not one year in five that we get rain enough to thoroughly soak the soil for several weeks after sowing the wheat in August or September. And when it does come, the season is so far advanced that the wheat plants make little growth."

My own opinion is, that on clayey land, manure will act much quicker if applied on, or near the surface, than if plowed under. Clay mixed with manure arrests or checks decomposition. Sand has no such effect. If anything, it favors a more active decomposition, and hence, manure acts much more rapidly on sandy land than on clay land. And I think, as a rule, where a farmer advocates the application of manure on the surface, it will be found that he occupies clay land or a heavy loam; while those who oppose the practice, and think manure should be plowed under, occupy sandy land or sandy loam.

"J. J. Thomas," said I, "once gave me a new idea."

"Is that anything strange," remarked the Deacon. "Are ideas so scarce among you agricultural writers, that you can recollect who first suggested them?"

"Be that as it may," said I, "this idea has had a decided influence on my farm practice. I will not say that the idea originated with Mr. Thomas, but at any rate, it was new to me. I had always been in the habit, when spading in manure in the garden, of putting the manure in the trench and covering it up; and in plowing it in, I thought it was desirable to put it at the bottom of the furrow where the next furrow would cover it up."

"Well," said the Deacon, "and what objection is there to the practice?"

"I am not objecting to the practice. I do not say that it is not a good plan. It may often be the only practicable method of applying manure. But it is well to know that there is *sometimes* a better plan. The idea that Mr. Thomas gave me, was, that it was very desirable to break up the manure fine, spread it evenly, and thoroughly mix it with the soil.

"After the manure is spread on the soil," said Mr. Thomas, "and before plowing it in, great benefit is derived by thoroughly harrowing the top-soil, thus breaking finely both the manure and the soil, and mixing them well together. Another way for the perfect diffusion of the manure among the particles of earth, is, to spread the manure in autumn, so that all the rains of this season may dissolve the soluble portions and carry them down among the particles, where they are absorbed and retained for the growing crop.

"In experiments," continues Mr. Thomas, "when the manure for corn was thus applied in autumn, has afforded a yield of about 70 bushels per acre, when the same amount applied in spring, gave only 50 bushels. A thin coating of manure applied to winter-wheat at the time of sowing, and was harrowed in, has increased the crop from 7 to 10 bushels per acre—and in addition to this, by the stronger growth it has caused, as well as by the protection it has afforded to the surface, it has not unfrequently saved the crop from partial or total winter-killing.

"In cases where it is necessary to apply coarse manures at once, much may be done in lessening the evils of coarseness by artificially grinding it into the soil. The instrument called the drag-roller—which is like the common roller set stiff so as not to revolve—has been used to great advantage for this purpose, by passing it over the surface in connection with the harrow. We have known this treatment to effect a thorough intermixture, and to more than double the crop obtained by common management with common manure."

TOP-DRESSING WITH MANURE.

The term "top-dressing" usually refers to sowing or spreading manures on the growing crop. For instance, we top-dress pastures or meadows by spreading manure on the surface. If we sow nitrate of soda, or guano, on our winter-wheat in the spring, that would be top-dressing. We often sow gypsum on clover, and on barley, and peas, while the plants are growing in the spring, and this is top-dressing.

"If the gypsum was sown broadcast on the land before sowing the seed," said the Deacon, "would not that be top-dressing also?"

Strictly speaking, I suppose that would not be top-dressing.

Top-dressing in the sense in which I understand the term, is seldom adopted, except on meadows and pastures as a regular system. It is an after-thought. We have sown wheat on a poor, sandy knoll, and we draw out some manure and spread on it in the winter or early spring; or we top-dress it with hen-manure, or guano, or nitrate of soda and superphosphate. I do not say that this is better than to apply the manure at the time of sowing the wheat, but if we neglect to do so, then top-dressing is a commendable practice.

Dr. Vœlcker reports the result of some experiments in top-dressing winter-wheat on the farm of the Royal Agricultural College at Cirencester, England. The manures were finely sifted and mixed with about ten times their weight of fine soil, and sown broadcast on the growing wheat, March 22. A fine rain occurred the following day, and washed the manure into the soil. The following is the yield per acre:—

No manure	27	bushels and	1984	lbs. of straw.
280 lbs. Peruvian guano	40	" "	2576	" "
195 " nitrate of soda	38	" "	2695	" "
180 " nitrate of soda, and 168 lbs. of common salt	40½	" "	2736	" "
448 lbs. Proctor's wheat-manure	39½	" "	2668	" "
672 " " " "	44¼	" "	3032	" "
4 tons chalk-marl	27	" "	1872	" "

The manures in each case cost $7.80 per acre, except the large dose of Proctor's wheat-manure, which cost $11.70 per acre. The wheat was worth $1.26 per bushel. Leaving the value of the straw out of the question, the profit from the use of the top-dressing was:

With guano	$8.70 per acre.
" nitrate of soda	6.00
" nitrate of soda and common salt	9.33
" 448 lbs. wheat-manure	7.94
" 672 " " "	10.16

The marl did no good.

The nitrate of soda and common salt contained no phosphoric acid, and yet produced an excellent effect. The guano and the wheat-manure contained phosphoric acid as well as nitrogen, and the following crop of clover would be likely to get some benefit from it.

John Johnston wrote in 1868, "I have used manure only as a top-dressing for the last 26 years, and I do think one load, used in that way, is worth far more than two loads plowed under on our stiff land."

CHAPTER XXXIII.

MANURES ON PERMANENT MEADOWS AND PASTURES.

In this country, where labor is comparatively high, and hay often commands a good price, a good, permanent meadow frequently affords as much real profit as any other portion of the farm. Now that we have good mowing-machines, tedders, rakes, and loading and unloading apparatus, the labor of hay-making is greatly lessened. The only difficulty is to keep up and increase the annual growth of good grass.

Numerous experiments on top-dressing meadows are reported from year to year. The results, of course, differ considerably, being influenced by the soil and season. The profit of the practice depends very much on the price of hay. In the Eastern States, hay generally commands a higher relative price than grain, and it not unfrequently happens that we can use manure on grass to decided advantage.

The celebrated experiments of Messrs. Lawes & Gilbert with "Manures on Permanent Meadow-land" were commenced in 1856, and have been continued on the same plots every year since that time.

"You need not be afraid, Deacon," said I, as the old gentleman commenced to button up his coat, "I am not going into the details of these wonderful experiments; but I am sure you will be interested in the results of the first six or seven years.

The following table explains itself:

Experiments with Manures on Permanent Meadow Land at Rothamsted, England.

	Description and Amount of Manures per Acre.	Annual Produce of Hay per Acre in lbs. 1856.	1857.	1858.	1859.	1860.	1861.	1862.	Average Hay per Acre. 1st 7 Yrs., 1856-62.	20 Years.	Hay per Acre the 20th Season, 1875. First Crop.	Second Crop.	Total Hay ℔ Acre.	
1	No manure..................	2433	2724	3116	2558	2822	3074	3238	2824	2534	2436	1491	3927	1
2	400 lbs. ammonia-salts = 82 lbs. of nitrogen..................	4028	3774	3982	3644	2940	3808	3854	3719	2940	2702	2016	4718	2
3	Superphosphate of lime........				2828	3176	3400	3252	(4 yrs.) 3164	(17 yrs.) 2492	2352	1722	4074	3
4	400 lbs. ammonia-salts and superphosphate of lime.........				4996	4788	4968	4756	(4 yrs.) 4877	(17 yrs.) 3612	4102	1610	5712	4
5	Mixed mineral manures..	3429	3666	4082	3416	3928	4488	4424	3919	3948	4564	2688	7252	5
6	400 lbs. ammonia-salts and mixed mineral manures......	6363	6422	7172	6198	5624	6316	6402	6357	5712	5824	2744	8568	6
7	800 lbs. ammonia-salts and mixed mineral manures......	7054	6940	7508	7150	5744	6710	7108	6876	6454	5222	5684	10,906	7
8	800 lbs. ammonia-salts and mixed mineral manures, including 200 lbs. each silicates, soda, and lime							7120		7000	6720	4592	11,312	8
9	275 lbs. nitrate of soda.....			2952	3588	3948	4092	4446	1858-62 3805	(18 yrs.) 3794	3360	1456	4816	9
10	550 lbs. nitrate of soda=82 lbs. of nitrogen			3564	4116	4410	4452	4086	4126	(18 yrs.) 3962	3276	1470	4746	10
11	Mixed mineral manures and 275 lbs. nitrate of soda.......			4236	4956	4812	5514	5178	4939	(18 yrs.) 5208	5040	1862	6902	11
12	Mixed mineral manures and 550 lbs. nitrate of soda...			5636	6072	5586	5892	5718	5783	(18 yrs.) 6384	7028	1974	9002	12
13	14 tons farmyard-manure.	4030	5328	4164	4584	5208	5052	5060	4775	4130	2996	1316	4312	13
14	14 tons farmyard-manure and 200 lbs. ammonia-salts........ ...	5009	6008	5320	5356	5704	5320	5556	5468	4816	3766	1960	5726	14

These are all the figures I will trouble you with. The "mixed mineral manures" consisted of superphosphate of lime (composed of 150 lbs. bone-ash and 150 lbs. sulphuric acid, sp. gr. 1.7), 300 lbs. sulphate of potash, 200 lbs. sulphate of soda, and 100 lbs. sulphate of magnesia. The ammonia-salts consisted of equal parts sulphate and muriate of ammonia, containing about 25 per cent. of ammonia. The manures were sown as early as possible in the spring, and, if the weather was suitable, sometimes in February. The farmyard-manure was spread on the land, in the first year, in the spring, afterwards in November or December. The hay was cut from the middle to the last of June; and the aftermath was pastured off by sheep in October.

"It is curious," said the Deacon, "that 400 lbs. of ammonia-salts should give as great an increase in the yield of hay the first year as 14 tons of farmyard-manure, but the second year the farmyard-manure comes out decidedly ahead."

"The farmyard-manure," said I, "was applied every year, at the rate of 14 gross tons per acre, for eight years—1856 to 1863. After 1863, this plot was left without manure of any kind. The average yield of this plot during the first 8 years was 4,800 lbs. of hay per acre.

On the plot dressed with 14 tons of farmyard-manure and 200 lbs. ammonia-salts, the average yield of hay for 8 years was 5,544 lbs. per acre. After the eighth year the farmyard-manure was discontinued, and during the next twelve years the yield of hay averaged 3,683 lbs., or 1,149 lbs. more than the continuously unmanured plot.

In 1859, superphosphate of lime was used alone on plot 3, and has been continued ever since. It seems clear that this land, which had been in pasture or meadow for a hundred years or more, was not deficient in phosphates.

"It does not seem," said the Deacon, "to have been deficient in anything. The twentieth crop, on the continuously unmanured plot was nearly 1¼ ton per acre, the first cutting, and nearly ¾-ton the second cutting. And apparently the land was just as rich in 1875, as it was in 1856, and yet over 25 tons of hay had been cut and *removed* from the land, without any manure being returned. And yet we are told that hay is a very exhausting crop."

"Superphosphate alone," said the Doctor, "did very little to increase the yield of hay, but superphosphate *and* ammonia produced the first year, 1859, over a ton more hay per acre than the superphosphate alone, and when *potash* is added to the manure, the yield is still further increased."

"Answer me one question," said the Deacon, "and let us leave the subject. In the light of these and other experiments, what do you consider the cheapest and best manure to apply to a permanent meadow or pasture?"

"Rich, well-decomposed farmyard or stable manure," said I, "and if it is not rich, apply 200 lbs. of nitrate of soda per acre, in addition. This will make it rich. Poor manure, made from straw, corn-stalks, hay, etc., is poor in nitrogen, and comparatively rich in potash. The nitrate of soda will supply the deficiency of nitrogen. On the sea-shore fish-scrap is a cheaper source of nitrogen, and may be used instead of the nitrate of soda."

CHAPTER XXXIV.

MANURES FOR SPECIAL CROPS.

MANURES FOR HOPS.

"For hops," said the Doctor, "there is nothing better than rich, well-decomposed farmyard-manure—such manure as you are now making from your pigs that are bedded with stable-manure."

"That is so," said I, "and the better you feed your horses and pigs, the better will the manure be for hops. In England, Mr. Paine, of Surrey, made a series of experiments with different manures for hops, and, as the result of four years trial, reported that *rape-cake*, singly, or in combination, invariably proved the best manure for hops. In this country, cotton-seed, or cotton-seed-cake, would be a good substitute for the rape-cake. Whatever manure is used should be used liberally. Hops require a large amount of labor per acre, and it is, therefore, specially desirable to obtain a large yield per acre. This can be accomplished only by the most lavish expenditure of manure. And all experience seems to show that it must be manure *rich in nitrogen.* In the hop districts of England, 25 tons of rich farmyard-manure are applied per acre; and in addition to this, soot and rags, both rich in nitrogen, have long been popular auxiliaries. The value of soot is due to the fact that it contains from 12 to 15 per cent of sulphate of ammonia, and the fact that it has been so long used with success as a manure for hops, seems to prove that sulphate of ammonia, which can now be readily obtained, could be used to advantage by our hop-growers—say at the rate, in addition to farm-yard manure, of 500 lbs. per acre, sown broadcast early in the spring.

MANURES FOR TOBACCO.

When tobacco is grown for wrappers, it is desirable to get a large, strong leaf. The richest land is selected for the crop, and large quantities of the richest and most stimulating manures are used.

Like cabbages, this crop requires a large amount of plant-food per acre; and, like them, it can only be grown by constant and high manuring. More manure must be used than the plants can take up out of the soil, and hence it is, that land which has been used for growing tobacco for some years, will be in high condition for other crops without further manuring.

Farm-yard or stable-manure, must be the mainstay of the tobacco-planter. With this, he can use artificial fertilizers to advantage—such as fish-scrap, woollen-rags, Peruvian guano, dried blood, slaughter-house offal, sulphate of ammonia, nitrate of soda, etc.

For choice, high-flavored smoking-tobacco, the grower aims to get quality rather than quantity. This seems to depend more on the land and the climate than on the manures used. Superphosphate of lime would be likely to prove advantageous in favoring the early growth and maturity of the crop. And in raising tobacco-plants in the seed-bed, I should expect good results from the use of superphosphate, raked into the soil at the rate of three or four lbs. per square rod.

MANURES FOR INDIAN CORN.

We know less about the manurial requirements of Indian corn, than of almost any other crop we cultivate. We know that wheat, barley, oats, and grasses, require for their maximum growth a liberal supply of available nitrogen in the soil. And such facts and experiments as we have, seem to indicate that the same is also true of Indian corn. It is, at any rate, reasonable to suppose that, as Indian corn belongs to the same botanical order as wheat, barley, oats, rye, timothy, and other grasses, the general manurial requirements would be the same. Such, I presume, is the case; and yet there seem to be some facts that would incline us to place Indian corn with the leguminous plants, such as clover, peas, and beans, rather than with the cereals, wheat, barley, oats, etc.

"Why so," asked the Deacon, "Indian corn does not have much in common with beans, peas, and clover?"

As we have shown, clover can get more nitrogen out of the soil, than wheat, barley, and oats. And the same is true of beans and peas, though probably not to so great an extent.

Now, it would seem that Indian corn can get more nitrogen out of a soil, than wheat, barley, or oats—and to this extent, at least, we may consider Indian corn as a renovating crop. In other words, the Indian corn can get more nitrogen out of the soil, than wheat, barley, and oats—and when we feed out the corn and stalks on the farm, we have more food and more manure than if we raised and fed out a crop of oats, barley, or wheat. If this idea is correct, then Indian corn, when consumed on the farm, should not be classed with what the English farmers term "white crops," but rather with the "green crops." In other words, Indian corn is what old writers used to call a "fallow crop"—or what we call a renovating crop.

If this is so, then the growth and consumption of Indian corn on the farm, as is the case with clover, should leave the farm richer for wheat, rather than poorer. I do not mean richer absolutely, but richer so far as the *available* supply of plant-food is concerned.

"It may be that you are right," said the Doctor, "when corn is grown for *fodder*, but not when grown for the grain. It is the formation of the seed which exhausts the soil."

If I could be sure that it was true of corn-fodder, I should have little doubt that it is true also of corn as ordinarily grown for grain and stalks. For, I think, it is clear that the grain is formed at the expense of the stalks, and not directly from the soil. The corn-fodder will take from the soil as much nitrogen and phosphoric acid as the crop of corn, and the more it will take, the more it approximates in character to clover and other renovating crops. If corn-fodder is a renovating crop, so is the ordinary corn-crop, also, provided it is consumed on the farm.

"But what makes you think," said the Deacon, "that corn can get more nitrogen from the soil, than wheat?"

"That is the real point, Deacon," said I, "and I will ask you this question. Suppose you had a field of wheat seeded down to clover, and the clover failed. After harvest, you plow up half of the field and sow it to wheat again, the other half of the field you plow in the spring, and plant with Indian corn. Now, suppose you get 15 bushels of wheat to the acre, how much corn do you think you would be likely to get?"

"Well, that depends," said the Deacon, "but I should expect at least 30 bushels of shelled corn per acre."

"Exactly, and I think most farmers would tell you the same;

you get twice as much corn and stalks to the acre as you would of wheat and straw. In other words, while the wheat cannot find more nitrogen than is necessary to produce 15 bushels of wheat and straw, the corn can find, and does find, take up, and organize, at least twice as much nitrogen as the wheat."

If these are facts, then the remarks we have made in regard to the value of clover as a fertilizing crop, are applicable in some degree to Indian corn. To grow clover and sell it, will in the end impoverish the soil; to grow clover and feed it out, will enrich the land. And the same will be true of Indian corn. It will gather up nitrogen that the wheat-crop can not appropriate; and when the corn and stalks are fed out, some 90 per cent of the nitrogen will be left in the manure.

"You do not think, then," said the Doctor, "that nitrogen is such an important element in manure for corn, as it is in a manure for wheat."

I have not said that. If we want a large crop of corn, we shall usually need a liberal supply of available nitrogen. But this is because a larger crop of corn means a much larger produce per acre, than a large crop of wheat. Forty bushels of wheat per acre is an unusually large crop with us; but 80 bushels of shelled corn can be grown in a favorable season, and on rich, well-cultivated land. As the Deacon has said, 30 bushels of corn per acre can be grown as easily as 15 bushels of wheat; and it is quite probable, in many cases, that a manure containing no nitrogen, might give us a crop of 35 or 40 bushels per acre. In other words, up to a certain point, manures containing mineral, or carbonaceous matter, might frequently, in ordinary agriculture, increase the yield of Indian corn; while on similar land, such manures would have little effect on wheat.

"That is so," said the Deacon, "we all know that plaster frequently increases the growth of corn, while it seldom does much good on wheat."

But, after you have got as large a crop as the land will produce, aided by plaster, ashes, and superphosphate, say 40 bushels of shelled corn per acre, *then* if you want to raise 70 bushels per acre, you must furnish the soil with manures containing sufficient available nitrogen.

Some years ago, I made some careful experiments with artificial manures on Indian corn.

"Oh, yes," said the Deacon, "they were made on the south lot, in front of my house, and I recollect that the N. Y. State Ag. Society awarded you a prize of $75 for them."

"And I recollect," said I, "how you and some other neighbors laughed at me for spending so much time in measuring the land and applying the manures, and measuring the crop. But I wish I could have afforded to continue them. A single experiment, however carefully made, can not be depended on. However, I will give the results for what they are worth, with some remarks made at the time:

"The soil on which the experiments were made, is a light, sandy loam. It has been under cultivation for upwards of twenty years, and so far as I can ascertain has never been manured. It has been somewhat impoverished by the growth of cereal crops, and it was thought that for this reason, and on account of its light texture and active character, which would cause the manures to act immediately, it was well adapted for the purpose of showing the effect of different manurial substances on the corn-crop.

"The land was clover-sod, two years old, pastured the previous summer. It was plowed early in the spring, and harrowed until in excellent condition. The corn was planted May 23, in hills 3½ feet apart each way.

"The manures were applied in the hill immediately before the seed was planted.

"With superphosphate of lime, and with plaster (gypsum, or *sulphate of lime*), the seed was placed directly on top of the manure, as it is well known that these manures do not injure the germinating principle of even the smallest seeds.

"The ashes were dropped in the hill, and then covered with soil, and the seed planted on the top, so that it should not come in contact with the ashes.

"Guano and sulphate of ammonia were treated in the same way.

"On the plots where ashes and guano, or ashes and sulphate of ammonia were both used, the ashes were first put in the hill, and covered with soil, and the guano or sulphate of ammonia placed on the top, and also covered with soil before the seed was planted. The ashes and superphosphate of lime was also treated in the same way. It is well known that unleached ashes, mixed either with guano, sulphate of ammonia, or superphosphate, mutually decompose each other, setting free the ammonia of the guano and sulphate of ammonia, and converting the soluble phosphate of the superphosphate of lime into the insoluble form in which it existed before treatment with sulphuric acid. All the plots were planted on the same day, and the manures weighed and applied under my own immediate supervision. Everything was done that was deemed necessary to secure accuracy.

"The following table gives the results of the experiments:

TABLE SHOWING THE RESULTS OF EXPERIMENTS ON INDIAN CORN.

No. of the plots.	DESCRIPTIONS OF MANURES AND QUANTITIES APPLIED PER ACRE.	*Bushels of ears of sound corn per acre.*	*Bushels of ears of soft corn per acre.*	*Total No. of bushels of ears of corn per acre.*	*Increase per acre of ears of sound corn.*	*Increase per acre of ears of soft corn.*	*Total increase per acre of ears of corn.*
1.	No manure	60	7	67	......	......	......
2.	100 lbs. plaster (gypsum or *sulphate of lime*)............................	70	8	78	10	1	11
3.	400 lbs. unleached wood-ashes and 100 lbs. plaster (mixed)............	68	10	78	8	3	11
4.	150 lbs. sulphate of ammonia........	90	15	105	30	8	38
5.	300 lbs. superphosphate of lime......	70	8	78	10	1	11
6.	150 lbs. sulphate of ammonia and 200 lbs. superphosphate of lime (mixed)	85	5	90	25	.....	23
7.	400 lbs. unleached wood-ashes, (uncertain)...............	60	12	72	......	5	5
8.	150 lbs. sulphate of ammonia and 400 lbs. unleached wood-ashes (sown separately)..	87	10	97	27	3	30
9.	300 lbs. superphosphate of lime, 150 lbs. sulph. ammonia, and 400 lbs. unleached wood-ashes............	100	8	108	40	1	41
10.	400 lbs. unleached wood-ashes...... ..	60	8	68	......	1	1
11.	100 lbs. plaster, 400 lbs. unleached wood-ashes, 300 lbs. superphosphate of lime, and 200 lbs. Peruvian guano...........	95	10	105	35	3	38
12.	75 lbs. sulphate of ammonia.........	78	10	88	18	3	21
13.	200 lbs. Peruvian guano.............	88	13	101	28	6	34
14.	400 lbs. unleached wood-ashes, 100 lbs. plaster, and 500 lbs. Peruvian guano.......................... .	111	14	125	51	7	58

"The superphosphate of lime was made on purpose for these experiments, and was a pure mineral manure of superior quality, made from calcined bones; it cost about 2½ cents per pound. The sulphate of ammonia was a good, commercial article, obtained from London, at a cost of about seven cents per pound. The ashes were made from beech and hard maple (*Acer saccharinum*) wood, and were sifted through a fine sieve before being weighed. The guano was the best Peruvian, costing about three cents per pound. It was crushed and sifted before using. In sowing the ashes on plot 7, an error occurred in their application, and for the purpose of checking the result, it was deemed advisable to repeat the experiment on plot 10.

"On plot 5, with 300 lbs. of superphosphate of lime per acre, the plants came up first, and exhibted a healthy, dark-green appearance, which they retained for some time. This result was not anticipated, though it is well known that superphosphate of lime has the effect of stimulating the germination of turnip-seed, and the early growth of the plants to an astonishing degree; yet, as it has no such effect on wheat, it appeared probable that it would not produce this effect on Indian corn, which, in chemical composition, is very similar to wheat. The result shows how uncertain are all speculations in regard to the manurial requirements of plants. This immediate effect of superphosphate of lime on corn was so marked, that the men (who were, at the time of planting, somewhat inclined to be skeptical, in regard to the value of such small doses of manure), declared that 'superphosphate beats all creation for corn.' The difference in favor of superphosphate, at the time of hoeing, was very perceptible, even at some distance.

"Although every precaution was taken that was deemed necessary, to prevent the manures from mixing in the hill, or from injuring the seed, yet, it was found, that those plots dressed with ashes and guano, or with ashes and sulphate of ammonia, were injured to some extent. Shortly after the corn was planted, heavy rain set in, and washed the sulphate of ammonia and guano, down into the ashes, and mutual decomposition took place, with more or less loss of ammonia. In addition to this loss of ammonia, these manures came up to the surface of the ground in the form of an excrescence, so hard that the plants could with difficulty penetrate through it.

"It will be seen, by examining the table, that although the superphosphate of lime had a good effect during the early stages of the growth of the plants, yet the increase of ears of corn in the end did not come up to these early indications. On plot 5, with 300 lbs. of superphosphate of lime per acre, the yield is precisely the same as on plot 2, with 100 lbs. of plaster (*sulphate of lime*), per acre. Now, superphosphate of lime is composed necessarily of soluble phosphate of lime and plaster, or sulphate of lime, formed from a combination of the sulphuric acid, employed in the manufacture of superphosphate, with the lime of the bones. In the 300 lbs. of superphosphate of lime, sown on plot 5, there would be about 100 lbs. of plaster; and as the effect of this dressing is no greater than was obtained from the 100 lbs. of plaster, sown on plot 2, it follows, that the good effect of the superphosphate of lime was due to the plaster that it contained.

"Again, on plot 4, with 150 lbs. of sulphate of ammonia per acre, we have 90 bushels of ears of sound corn, and 15 bushels of ears of soft corn, ('nubbins,') per acre; or a total increase over the plot without manure, of 38 bushels. Now, the sulphate of ammonia contains no phosphate of lime, and the fact that such a manure gives a considerable increase of crop, confirms the conclusion we have arrived at, from a comparison of the results on plots 2 and 5; that the increase from the superphosphate of lime, is not due to the phosphate of lime which it contains, unless we are to conclude that the sulphate of ammonia rendered the phosphate of lime in the soil more readily soluble, and thus furnished an increased quantity in an available form for assimilation by the plants—a conclusion, which the results with superphosphate alone, on plot 5, and with superphosphate and sulphate of ammonia, combined, on plot 6, do not sustain.

"On plot 12, half the quantity of sulphate of ammonia, was used as on plot 4, and the increase is a little more than half what it is where double the quantity was used. Again, on plot 13, 200 lbs. of Peruvian guano per acre, gives nearly as great an increase of sound corn, as the 150 lbs. of sulphate of ammonia. Now, 200 lbs. of Peruvian guano contains nearly as much ammonia as 150 lbs. sulphate of ammonia, and the increase in both cases is evidently due to the ammonia of these manures. The 200 lbs. of Peruvian guano, contained about 50 lbs. of phosphate of lime; but as the sulphate of ammonia, which contains no phosphate of lime, gives as great an increase as the guano, it follows, that the phosphate of lime in the guano, had little, if any effect; a result precisely similar to that obtained with superphosphate of lime.

"We may conclude, therefore, that on this soil, which has never been manured, and which has been cultivated for many years with the *Ceralia*—or, in other words, with crops which remove a large quantity of phosphate of lime from the soil—the phosphate of lime, relatively to the ammonia, is not deficient. If such was not the case, an application of soluble phosphate of lime would have given an increase of crop, which we have shown was not the case in any one of these experiments.

"Plot 10, with 400 lbs. of unleached wood-ashes per acre, produces the same quantity of *sound corn*, with an extra bushel of 'nubbins' per acre, as plot 1, without any manure at all; ashes, therefore, applied alone, may be said to have had no effect whatever. On plot 3, 400 lbs. of ashes, and 100 lbs. of plaster, give the same total number of bushels per acre, as plot 2, with 100 lbs. of plaster alone. Plot 8, with 400 lbs. ashes, and 150 lbs. of sulphate of ammonia, yields three bushels of sound corn, and five bushels of 'nubbins' per acre, *less* than plot 4, with 150 lbs. sulphate of ammonia alone. This result may be ascribed to the fact previously alluded to—the ashes dissipated some of the ammonia.

"Plot 11, with 100 lbs. of plaster, 400 lbs. ashes, 300 lbs. of superphosphate of lime, and 200 lbs. Peruvian guano (which contains about as much ammonia as 150 lbs. sulphate of ammonia), produced precisely the same number of total bushels per acre, as plot 4, with 150 lbs. sulphate of ammonia alone, and but 4 bushels more per acre, than plot 13, with 200 lbs. Peruvian guano alone. It is evident, from these results, that neither ashes nor phosphates had much effect on Indian corn, on this impoverished soil. Plot 14 received the largest dressing of ammonia (500 lbs. Peruvian guano), and produced much the largest crop; though the increase is not so great in proportion to the guano, as where smaller quantities were used.

"The manure which produced the most profitable result, was the 100 lbs. of plaster, on plot 2. The 200 lbs. of Peruvian guano, on plot 13, and which cost about $6, gave an increase of 14 bushels of shelled corn, and 6 bushels of 'nubbins.' This will pay at the present price of corn in Rochester, although the profit is not very great. The superphosphate of lime, although a very superior article, and estimated at cost price, in no case paid for itself. The same is true of the ashes.

"But the object of the experiment was not so much to ascertain what manures will pay, but to ascertain, if possible, what constituents of manures are required, in greatest quantity, for the maximum growth of corn. * * Hitherto, no experiments have been made in this country, on Indian corn, that afforded any certain information on this point. Indeed, we believe no satisfactory experiments have been made on Indian corn, in any country, that throw any definite light on this interesting and important question. A few years ago, Mr. Lawes made similar experiments to those given above, on his farm, at Rothamsted, England; but owing to the coolness of the English climate, the crop did not arrive at maturity.

"Numerous experiments have been made in this country, with guano and superphosphate of lime; but the superphosphates used were commercial articles, containing more or less ammonia, and if they are of any benefit to those crops to which they are applied, it is a matter of uncertainty whether the beneficial effect of the application is due to the soluble phosphate of lime, or to the ammonia. On the other hand, guano contains both ammonia and phosphate; and we are equally at a loss to determine, whether the effect is attributable to the ammonia or phosphate, or both. In order, therefore, to determine satisfactorily, which of the several ingredients of plants is required in greatest proportion, for the maximum growth of any particular crop, we must apply these ingredients separately, or in such definite compounds, as will enable us to determine to what particular element or compounds the beneficial effect is to be ascribed. It was for this reason, that sulphate of ammonia, and a purely mineral superphosphate of lime, were used in the above experiments. No one would think of using sulphate of ammonia at its price, [sulphate of ammonia is now cheaper, while Peruvian guano is more costly and less rich in ammonia], as an ordinary manure, for the reason, that the same quantity of ammonia can be obtained in other substances, such as barnyard-manure, Peruvian guano, etc., at a much cheaper rate. But these manures contain *all* the elements of plants, and we can not know whether the effect produced by them is due to the ammonia, phosphates, or any other ingredients. For the purpose of experiment, therefore, we must use a manure that furnishes ammonia without any admixture of phosphates, potash, soda, lime, magnesia, etc., even though it cost much more than we could obtain the same amount of ammonia in other manures. I make these remarks in order to correct a very common opinion, that if experiments do not *pay*, they are useless. The ultimate object, indeed, is to ascertain the most profitable method of manuring; but the *means* of obtaining this information, can not in all cases be profitable.

"Similar experiments to those made on Indian corn, were made on soil of a similar character, on about an acre of Chinese sugar-cane. I do not propose to give the results in detail, at this time, and allude to them merely to mention one very important fact, *the superphosphate of lime had a very marked effect.* This manure was applied in the hill on one plot (the twentieth of an acre,) at the rate of 400 lbs. per acre, and the plants on this plot came up first, and outgrew all the others from the start, and ultimately attained the height of about ten feet; while on the plot receiving no manure, the plants were not five feet high. This is a result entirely different from what I should have expected. It has been supposed, from the fact that superphosphate of lime had no effect on wheat, that it would probably have little effect on corn, or on the sugar-cane, or other *ceralia;* and that, as ammonia is so beneficial for wheat, it would probably be beneficial for corn and sugar-cane. The above experiments indicate that such is the case, in regard to Indian corn, so far as the production of grain is concerned, though, as we have stated, it is not true in reference to the early growth of the plants. The superphosphate of lime on Indian corn, stimulated the growth of the plants, in a very decided manner at first, so much so, that we were led to suppose, for some time, that it would give the largest crop; but at harvest, it was found that it produced no more corn than plaster. These results seem to indicate, that superphosphate of lime stimulates the growth of stalks and leaves, and has little effect in increasing the production of seed. In raising Indian corn, for fodder or for soiling purposes, superphosphate of lime may be beneficial, as well as in growing the sorghum for sugar-making purposes, or for foddder—though, perhaps, not for seed."

"In addition to the experiments given above, I also made the same season, on an adjoining field, another set of experiments on Indian corn, the results of which are given below.

"The land on which these experiments were made, is of a somewhat firmer texture than that on which the other set of experiments was made. It is situated about a mile from the barn-yard, and on this account, has seldom, if ever been manured. It has been cultivated for many years with ordinary farm crops. It was plowed early in the spring, and it was harrowed until quite mellow. The corn was planted May 30, 1857. Each experiment occupied one-tenth of an acre, consisting of 4 rows 3½ feet apart, and the same distance between the hills in the rows, with one row without manure between each experimental plot.

"The manure was applied in the hill, in the same manner as in the first set of experiments.

"The barnyard-manure was well-rotted, and consisted principally of cow-dung with a little horse-dung. Twenty two-horse wagon loads of this was applied per acre, and each load would probably weigh about one ton. It was put in the hill and covered with soil, and the seed then planted on the top.

"The following table gives the results of the experiments:

TABLE SHOWING THE RESULTS OF EXPERIMENTS ON INDIAN CORN, MADE NEAR ROCHESTER, N. Y, IN THE YEAR 1857.

No. of the Plots.	DESCRIPTIONS OF MANURES, AND QUANTITIES APPLIED PER ACRE.	*Bushels of ears of sound corn per acre.*	*Bushels of ears of soft corn per acre.*	*Total No. of bushels of ears of corn per acre.*	*Inc. ears sound corn per acre over unmanured plot.*	*Inc. ears of soft corn per acre over unmanured plot.*	*Total increase of ears of corn per acre.*
1.	No manure	75	12	87	.....	......	.....
2.	20 loads barn-yard manure	82½	10	92½	5½	......	5½
3.	150 lbs. sulphate of ammonia	85	30	115	10	18	28
4.	300 lbs. superphosphate of lime	88	10	98	11	......	11
5.	400 lbs. Peruvian guano	90	30	120	15	18	33
6.	400 lbs. of "Cancerine," or fish man'e	85	20	105	10	8	18

"As before stated, the land was of a stronger nature than that on which the first set of experiments was made, and it was evidently in better condition, as the plot having no manure produced 20 bushels of ears of corn per acre more than the plot without manure in the other field.

"On plot 4, 300 lbs. of superphosphate of lime gives a total increase of 11 bushels of ears of corn per acre over the unmanured plot, agreeing exactly with the increase obtained from the same quantity of the same manure on plot 5, in the first set of experiments.

"Plot 3, dressed with 150 lbs. of sulphate of ammonia per acre, gives a total increase of 28 bushels of ears of corn per acre, over the unmanured plot; and an increase of 22½ bushels of ears per acre over plot 2, which received 20 loads of good, well-rotted barn-yard-dung per acre.

"Plot 5, with 400 lbs. of Peruvian guano per acre gives the best crop of this series viz: an increase of 33 bushels of corn per acre over the unmanured plot, and 27½ over the plot manured with 20 loads of barnyard-dung. The 400 lbs. of 'Cancerine'—an artificial manure made in New Jersey from fish—gives a total increase of 18 bushels of ears per acre over the unmanured plot, and 12½ bushels more than that manured with barn-yard dung, though 5 bushels of ears of sound corn and 10 bushels of 'nubbins' per acre *less* than the same quantity of Peruvian guano."

MANURES FOR TURNIPS.

To raise a large crop of turnips, especially of ruta-bagas, there is nothing better than a liberal application of rich, well-rotted farm-yard-manure, and 250 to 300 lbs. of good superphosphate of lime per acre, *drilled in with the seed.*

I have seen capital crops of common turnips grown with no other manure except 300 lbs. of superphosphate per acre, drilled with the seed. Superphosphate has a wonderful effect on the development of the roots of the turnip. And this is the secret of its great value for this crop. It increases the growth of the young plant, developing the formation of the roots, and when the turnip once gets full possession of the soil, it appropriates all the plant-food it can find. A turnip-crop grown with superphosphate, can get from the soil much more nitrogen than a crop of wheat. The turnip-crop, when supplied with superphosphate, is a good "scavenger." It will gather up and organize into good food the refuse plant-food left in the soil. It is to the surface soil, what clover is to the subsoil.

To the market gardener, or to a farmer who manures heavily, common turnips drilled in with superphosphate will prove a valuable crop. On such land no other manure will be needed. I cannot too earnestly recommend the use of superphosphate as a manure for turnips.

For Swede turnips or ruta-bagas, it will usually be necessary, in order to secure a maximum crop, to use a manure which, in addition to superphosphate, contains available nitrogen. A good dressing of rich, well-rotted manure, spread on the land, and plowed under, and then 300 lbs. of superphosphate drilled in with the seed, would be likely to give a good crop.

In the absence of manure, there is probably nothing better for the ruta-bagas than 300 lbs. of so-called "rectified" Peruvian guano, that is, guano treated with sulphuric acid, to render the phosphates soluble. Such a guano is guaranteed to contain 10 per cent of ammonia, and 10 per cent of soluble phosphoric acid, and would be a good dressing for Swede turnips.

The best way to use guano for turnips is to sow it broadcast on the land, and harrow it in, and then either drill in the turnip-seed on the flat, or on ridges. The latter is decidedly the better plan, provided you have the necessary implements to do the work expeditiously. A double mould-board plow will ridge up four acres a day, and the guano being previously sown on the surface, will be turned up with the mellow surface-soil into the ridge, where the seed is to be sown. The young plants get hold of it and grow so rapidly as to be soon out of danger from the turnip-beetle.

MANURES FOR MANGEL-WURZEL OR SUGAR-BEETS.

When sugar-beets are grown for feeding to stock, there is probably little or no difference in the manurial requirements of sugar-beets and mangel-wurzel. Our object is to get as large a growth as possible consistent with quality.

"Large roots," said the Deacon, "have been proved to contain less nutriment than small roots."

True, but it does not follow from this that rich land, or heavy manuring is the chief cause of this difference. It is much more likely to be due to the variety selected. The seed-growers have been breeding solely for size and shape. They have succeeded to such an extent that 84 gross tons of roots have been grown on an acre. This is equal to over 94 of our tons per acre. "That is an enormous crop," said the Deacon; "and it would require some labor to put 10 acres of them in a cellar."

"If they were as nutritious as ordinary mangels," said I, "that would be no argument against them. But such is not the case. In a letter just received from Mr. Lawes, (May, 1878,) he characterizes them as 'bladders of water and salts.'"

Had the seed-growers bred for *quality*, the roots would have been of less size, but they would contain more nutriment.

What we want is a variety that has been bred with reference to quality; and when this is secured, we need not fear to make the land rich and otherwise aim to secure great growth and large-sized roots.

It certainly is not good economy to select a variety which has been bred for years to produce large-sized roots, and then sow this seed on poor land for the purpose of obtaining small-sized roots. Better take a variety bred for quality, and then make the land rich enough to produce a good crop.

We are not likely to err in making the land too rich for mangel-wurzel or for sugar-beets grown for stock. When sugar-beets are grown for sugar, we must aim to use manures favorable for the production of sugar, or rather to avoid using those which are unfavorable. But where sugar-beets are grown for food, our aim is to get a large amount of nutriment to the acre. And it is by no means clear to my mind that there is much to be gained by selecting the sugar-beet instead of a good variety of mangel-wurzel. It is not a difficult matter, by selecting the largest roots for seed, and by liberal manuring, and continuously selecting the largest roots, to convert the sugar-beet into a mangel-wurzel.

When sugar-beets are grown for food, we may safely manure them as we would mangel-wurzel, and treat the two crops precisely alike.

I usually raise from ten to fifteen acres of mangel-wurzel every year. I grow them in rotation with other crops, and not as the Hon. Harris Lewis and some others do, continuously on the same land. We manure liberally, but not extravagantly, and get a fair yield, and the land is left in admirable condition for future crops.

I mean by this, not that the land is specially rich, but that it is very clean and mellow.

"In 1877," said the Deacon, "you had potatoes on the land where you grew mangels the previous year, and had the best crop in the neighborhood."

This is true, but still I do not think it a good rotation. A barley crop seeded with clover would be better, especially if the mangels were heavily manured. The clover would get the manure which had been washed into the subsoil, or left in such a condition that potatoes or grain could not take it up.

There is one thing in relation to my mangels of 1876 which has escaped the Deacon. The whole piece was manured and well prepared, and dibbled in with mangels, the rows being 2½ feet apart, and the seed dropped 15 inches apart in the rows. Owing to poor seed, the mangels failed on about three acres, and we plowed up the land and drilled in corn for fodder, in rows 2½ feet apart, and at the rate of over three bushels of seed per acre. We had a *great crop* of corn-fodder.

The next year, as I said before, the whole piece was planted with potatoes, and if it was true that mangels are an "enriching crop," while corn is an "exhausting" crop, we ought to have had much better potatoes after the mangels than after corn. This was certainly not the case; if there was any difference, it was in favor of the corn. But I do not place any confidence in an experiment of this kind, where the crops were not weighed and the results carefully ascertained.

Mr. Lawes has made some most thorough experiments with different manures on sugar-beets, and in 1876 he commenced a series of experiments with mangel-wurzel.

The land is a rather stiff clay loam, similar to that on which the wheat and barley experiments were made. It is better suited to the growth of beets than of turnips.

"Why so," asked the Deacon, "I thought that black, bottom land was best for mangels."

"Not so, Deacon," said I, "we can, it is true, grow large crops of mangels on well-drained and well-manured swampy or bottom land, but the best soil for mangels, especially in regard to quality, is a good, stiff, well-worked, and well-manured loam."

"And yet," said the Deacon, "you had a better crop last year on the lower and blacker portions of the field than on the heavy, clayey land."

In one sense, this is true. We had dry weather in the spring, and the mangel seed on the dry, clayey land did not come up as well as on the cooler and moister bottom-land. We had more plants to the acre, but the roots on the clayey land, when they once got fair hold of the soil and the manure, grew larger and better than on the lighter and moister land. The great point is to get this heavy land into a fine, mellow condition.

But to Mr. Lawes' experiments. They are remarkably interesting and instructive. But it is not necessary to go into all the details. Suffice it to say that the experiments seem to prove, very conclusively, that beets require a liberal supply of available nitrogen. Thus, without manure, the yield of beets was about 7½ tons of bulbs per acre.

With 550 lbs. nitrate of soda per acre, the yield was a little over 22 tons per acre. With 14 tons of farmyard-manure, 18 tons per acre. With 14 tons of farmyard-manure and 550 lbs. nitrate of soda, over 27½ tons per acre.

Superphosphate of lime, sulphates of potash, soda, and magnesia, and common salt, alone, or with other manures, had comparatively little effect.

Practically, when we want to grow a good crop of beets or mangels, these experiments prove that what we need is the richest kind of barnyard-manure.

If our manure is not rich, then we should use, in addition to the manure, a dressing of nitrate of soda—say 400 or 500 lbs. per acre. If the land is in pretty good condition, and we have no barnyard-manure, we may look for a fair crop from a dressing of nitrate of soda alone.

"I see," said the Deacon, "that 550 lbs. of nitrate of soda alone, gave an increase of 14½ tons per acre. And the following year, on the same land, it gave an increase of 13½ tons; and the next year, on the same land, over 9 tons."

"Yes," said I, "the first three years of the experiments (1871–2–3), 550 lbs. of nitrate of soda alone, applied every year, gave an average yield of 19¼ tons of bulbs per acre. During the same three years, the plot dressed with 14 tons of barnyard-manure, gave an average yield of 16¼ tons. But now mark. The next year (1874) all the plots were left without any manure, and the plot which had been previously dressed with nitrate of soda, alone, fell off to 3 tons per acre, while the plot which had been previously manured with barnyard-manure, produced 10¾ tons per acre."

"Good," said the Deacon, "there is nothing like manure."

MANURES FOR CABBAGE, PARSNIPS, CARROTS, LETTUCE, ONIONS, ETC.

I class these plants together, because, though differing widely in many respects, they have one feature in common. They are all artificial productions.

A distinguished amateur horticulturist once said to me, "I do not see why it is I have so much trouble with lettuce. My land is rich, and the lettuce grow well, but do not head. They have a tendency to run up to seed, and soon get tough and bitter."

I advised him to raise his own seed from the best plants—and especially to reject all plants that showed any tendency to go prematurely to seed. Furthermore, I told him I thought if he would sow a little superphosphate of lime with the seed, it would greatly stimulate the *early* growth of the lettuce.

As I have said before, superphosphate, when drilled in with the seed, has a wonderful effect in developing the root-growth of the young plants of turnips, and I thought it would have the same effect on lettuce, cabbage, cauliflowers, etc.

"But," said he, "it is not *roots* that I want, but heads."

"Exactly," said I, "you do not want the plants to follow out their natural disposition and run up to seed. You want to induce them to throw out a great abundance of tender leaves. In other words, you want them to 'head.' Just as in the turnip, you do not want them to run up to seed, but to produce an unnatural development of 'bulb.'"

Thirty years ago, Dr. Gilbert threw out the suggestion, that while it was evident that turnips required a larger proportion of soluble phosphates in the soil than wheat; while wheat required a larger proportion of available nitrogen in the soil, than turnips, it was quite probable, if we were growing turnips *for seed*, that then, turnips would require the same kind of manures as wheat.

We want exceedingly rich land for cabbage, especially for an early crop. This is not merely because a large crop of cabbage takes a large amount of plant-food out of the soil, but because the cultivated cabbage is an artificial plant, that requires its food in a concentrated shape. In popular language, the plants have to be "forced."

According to the analyses of Dr. Anderson, the outside leaves of cabbage, contain, in round numbers, 91 per cent of water; and the heart leaves, 94½ per cent. In other words, the green leaves contain 3½ per cent more dry matter than the heart leaves.

Dr. Vœlcker, who analyzed more recently some "cattle-cabbage," found 89½ per cent of water in the green leaves, and 83¾ per cent in the heart and inner leaves—thus confirming previous analyses, and showing also that the composition of cabbages varies considerably.

Dr. Vœlcker found much less water in the cabbage than Dr. Anderson.

The specimen analyzed by Dr. V., was grown on the farm of the Royal Ag. College of England, and I infer from some incidental remarks, that the crop was grown on rather poor land. And it is probably true that a large crop of cabbage grown on rich land, contains a higher percentage of water than cabbage grown on poorer land. On the poor land, the cabbage would not be likely to head so well as on the rich land, and the green leaves of cabbage contain more than half as much again real dry substance as the heart leaves.

The dry matter of the heart leaves, however, contains more actual nutriment than the dry matter of the green leaves.

It would seem very desirable, therefore, whether we are raising cabbage for market or for home consumption, to make the land rich enough to grow good heads. Dr. Vœlcker says, "In ordinary seasons, the average produce of Swedes on our poorer fields is about 15 tons per acre. On weighing the produce of an acre of cabbage, grown under similar circumstances, I found that it amounted to 17½ tons per acre. On good, well-manured fields, however, we have had a much larger produce."

In a report on the "Cultivation of Cabbage, and its comparative Value for Feeding purposes," by J. M. M'Laren, of Scotland, the yield of Swede turnips, was 29¾ tons per acre, and the yield of cabbage, 47¾ tons per acre.

"It is very evident," said the Deacon, "that if you grow cabbage you should make the land rich enough to produce a good crop—and I take it that is all you want to show."

"I want to show," I replied, "that our market gardeners have reason for applying such apparently excessive dressings of rich manure to the cabbage-crop. They find it safer to put far more manure into the land than the crop can possibly use, rather than run any risk of getting an inferior crop. An important practical question is, whether they can not grow some crop or crops after the cabbage, that can profitably take up the manure left in the soil."

Prof. E. Wolff, in the last edition of "Praktische Düngerlehre," gives the composition of cabbage. For the details of which, see Appendix, page 345.

From this it appears that 50 tons of cabbage contain 240 lbs. of nitrogen, and 1,600 lbs. of ash. Included in the ash is 630 lbs. of potash; 90 lbs. of soda; 310 lbs. of lime; 60 lbs. of magnesia; 140 lbs. of phosphoric acid; 240 lbs. of sulphuric acid, and 20 lbs. of silica.

Henderson, in "Gardening for Profit," advises the application of 75 tons of stable or barn-yard manure per acre, for early cabbage. For late cabbage, after peas or early potatoes, he says about 10 tons per acre are used.

Brill, in "Farm Gardening and Seed Growing," also makes the same distinction in regard to the quantity of manure used for early and late cabbage. He speaks of 70 to 80 tons or more, per acre, of well-rotted stable-manure as not an unusual or excessive dressing every year.

Now, according to Wolff's table, 75 tons of fresh stable-manure, with straw, contains 820 lbs. of nitrogen; 795 lbs. of potash; 150 lbs. soda; 315 lbs. of lime; 210 lbs. of magnesia; 420 lbs. of phosphoric acid; 105 lbs. sulphuric acid; 2,655 lbs. of silica, and 60 lbs. of chlorine.

"Put the figures side by side," said the Deacon, "so that we can compare them."

Here they are:

	75 tons Fresh Horse Manure.	*50 tons Cabbage.*
Nitrogen	820 lbs.	240 lbs.
Potash	795 "	630 "
Phosphoric acid	420 "	140 "
Soda	150 "	90 "
Lime	315 "	310 "
Magnesia	210 "	60 "

"That is rather an interesting table," said the Doctor. "In the case of lime, the crop takes about all that this heavy dressing of manure supplies—but I suppose the soil is usually capable of furnishing a considerable quantity."

"That may be so," said the Deacon, "but all the authorities on market gardening speak of the importance of either growing cabbage on land containing lime, or else of applying lime as a manure. Quinn, who writes like a sensible man, says in his book, 'Money in the Garden,' 'A top-dressing of lime every third year, thirty or forty bushels per acre, spread broadcast, and harrowed in, just before planting, pays handsomely.'"

Henderson thinks cabbage can only be grown successfully on land containing abundance of lime. He has used heavy dressings of lime on land which did not contain shells, and the result was satisfactory for a time, but he found it too expensive.

Experience seems to show that to grow large crops of perfect cabbage, the soil must be liberally furnished with manures rich in nitrogen and phosphoric acid.

In saying this, I do not overlook the fact that cabbage require a large quantity of potash. I think, however, that when large quantities of stable or barn-yard manure is used, it will rarely be found that the soil lacks potash.

What we need to grow a large crop of cabbage, is manure from well-fed animals. Such manure can rarely be purchased. Now, the difference between rich manure and ordinary stable or barn-yard-manure, consists principally in this: The rich manure contains more nitrogen and phosphoric acid than the ordinary stable-manure—and it is in a more available condition.

To convert common manure into rich manure, therefore, we must add nitrogen and phosphoric acid. In other words, we must use Peruvian guano, or nitrate of soda and superphosphate, or bone-dust, or some other substance that will furnish available nitrogen and phosphoric acid.

Or it may well be, where stable-manure can be bought for $1.00 per two-horse load, that it will be cheaper to use it in larger quantity rather than to try to make it rich. In this case, however, we must endeavor to follow the cabbage by some crop that has the power of taking up the large quantity of nitrogen and other plant-food that will be left in the soil.

The cabbage needs a large supply of nitrogen in the soil, but removes comparatively little of it. We see that when 75 tons of manure is used, a crop of 50 tons of cabbage takes out of the soil less than 30 per cent of the nitrogen. And yet, if you plant cabbage on this land, the next year, without manure, you would get a small crop.

"It cannot be for want of nitrogen," said the Deacon.

"Yes it can," said I. "The cabbage, especially the early kinds, must have in the soil a much larger quantity of available nitrogen than the plants can use."

I do not mean by this that a large crop of cabbage could be raised, year after year, if furnished only with a large supply of available nitrogen. In such a case, the soil would soon lack the necessary inorganic ingredients. But, what I mean, is this: Where land has been heavily manured for some years, we could often raise a good crop of cabbage by a liberal dressing of available nitrogen, and still more frequently, if nitrogen and phosphoric acid were both used.

You may use what would be considered an excessive quantity of ordinary stable-manure, and grow a large crop of cabbage; but still, if you plant cabbage the next year, without manure of any kind, you will get a small crop; but dress it with a manure containing the necessary amount of nitrogen, and you will, so far as the supply of plant-food is concerned, be likely to get a good crop.

In such circumstances, I think an application of 800 lbs. of nitrate of soda per acre, costing, say $32, would be likely to afford a very handsome profit.

For lettuce, in addition to well prepared rich land, I should sow 3 lbs. of superphosphate to each square rod, scattered in the rows before drilling in the seed. It will favor the formation of fibrous roots and stimulate the growth of the young plants.

In raising onions from seed, we require an abundance of rich, well-rotted manure, clean land, and early sowing.

Onions are often raised year after year on the same land. That this entails a great waste of manure, is highly probable, but it is not an easy matter to get ordinary farm-land properly prepared for onions. It needs to be clean and free from stones and rubbish of all kinds, and when once it is in good condition, it is thought better to continue it in onions, even though it may entail more or less loss of fertility.

"What do you mean," asked the Deacon, "by loss of manure?"

"Simply this," said I. "We use a far greater amount of plant-food in the shape of manure than is removed by the crop of onions. And yet, notwithstanding this fact, it is found, as a matter of experience, that it is absolutely necessary, if we would raise a large and profitable crop, to manure it every year."

A few experiments would throw much light on this matter. I should expect, when land had been heavily dressed every year for a few years, with stable-manure, and annually sown to onions, that 800 lbs. of sulphate of ammonia, or of nitrate of soda, or 1,200 lbs. of Peruvian guano would give as good a crop as 25 or 30 tons of manure. Or perhaps a better plan would be to apply 10 or 15 loads of manure, and 600 lbs. of guano, or 400 lbs. sulphate of ammonia.

CHAPTER XXXV.

MANURES FOR GARDENS AND ORCHARDS.

MANURE FOR MARKET-GARDENS.

The chief dependence of the market-gardener must be on the stable-manure which he can obtain from the city or village. The chief defect of this manure is that it is not rich enough in available nitrogen. The active nitrogen exists principally in the urine, and this in our city stables is largely lost. A ton of fresh, unmixed horse-dung contains about 9 lbs. of nitrogen. A ton of horse-urine, 31 lbs. But this does not tell the whole story. The nitrogen in the dung is contained in the crude, undigested portions of the food. It is to a large extent insoluble and unavailable, while the nitrogen in the urine is soluble and active.

The market-gardener, of course, has to take such manure as he can get, and the only points to be considered are (1), whether he had better continue to use an excessive quantity of the manure, or (2), to buy substances rich in available nitrogen, and either mix them with the manure, or apply them separately to the soil, or (3), whether he can use this horse-manure as bedding for pigs to be fed on rich nitrogenous food.

The latter plan I adopt on my own farm, and in this way I get a very rich and active manure. I get available nitrogen, phosphoric acid, and potash, at far cheaper rates than they can be purchased in the best commercial fertilizers.

Pigs void a large amount of urine, and as pigs are ordinarily kept, much of this liquid is lost for want of sufficient bedding to absorb it. With the market-gardener or nurseryman, who draws large quantities of horse-manure from the city, this need not be the case. The necessary buildings can be constructed at little cost, and the horse-manure can be used freely. The pigs should be fed on food rich in nitrogen, such as bran, malt-combs, brewers' grains, the refuse animal matter from the slaughter-houses or butchers' stores, fish scrap, pea or lentil-meal, palm-nut cake, or such food as will furnish the most nitrogenous food, other things being equal, at the cheapest rate.

The market-gardener not only requires large quantities of rich manure, but he wants them to act quickly. The nurseryman who sets out a block of trees which will occupy the ground for three, four, or five years, may want a "lasting manure," but such is not the case with the gardener who grows crops which he takes off the land in a few months. As long as he continues to use horse or cow-manure freely, he need not trouble himself to get a slow or lasting manure. His great aim should be to make the manure as active and available as possible. And this is especially the case if he occupies clayey or loamy land. On sandy land the manure will decompose more rapidly and act quicker.

"There are many facts," said the Doctor, "that show that an artificial application of water is equivalent to an application of manure. It has been shown that market-gardeners find it necessary to apply a much larger amount of plant-food to the soil than the crops can take up. This they have to do year after year. And it may well be that, when a supply of water can be had at slight cost, it will be cheaper to irrigate the land, or water the plants, rather than to furnish such an excess of manure, as is now found necessary. Even with ordinary farm-crops, we know that they feel the effects of drouth far less on rich land than on poor land. In other words, a liberal supply of plant-food enables the crops to flourish with less water; and, on the other hand, a greater supply of water will enable the crops to flourish with a less supply of plant-food. The market-gardeners should look into this question of irrigation.

MANURES FOR SEED-GROWING FARMS.

In growing garden and vegetable seeds, much labor is necessarily employed per acre, and consequently it is of great importance to produce a good yield. The best and cleanest land is necessary to start with, and then manures must be appropriately and freely used.

"But not too freely," said the Doctor, "for I am told it is quite possible to have land too rich for seed-growing."

It is not often that the land is too rich. Still, it may well be that for some crops too much stable-manure is used. But in nine cases out of ten, when such manure gives too much growth and too little or too poor seed, the trouble is in the quality of the manure. It contains too much carbonaceous matter. In other words, it is so poor in nitrogen and phosphoric acid, that an excessive quantity has to be used.

The remedy consists in making richer manures and using a less quantity, or use half the quantity of stable-manure, and apply the rectified or prepared Peruvian guano, at the rate of 300 lbs. or 400 lbs. per acre, or say 200 lbs. superphosphate and 200 lbs. nitrate of soda per acre.

Where it is very important to have the seeds ripen early, a liberal dressing, say 400 lbs. per acre, of superphosphate of lime, will be likely to prove beneficial.

MANURE FOR PRIVATE GARDENS.

I once had a small garden in the city, and having no manure, I depended entirely on thorough cultivation and artificial fertilizers, such as superphosphate and sulphate of ammonia. It was cultivated not for profit, but for pleasure, but I never saw a more productive piece of land. I had in almost every case two crops a year on the same land, and on some plots three crops. No manure was used, except the superphosphate and sulphate of ammonia, and coal and wood ashes from the house.

About 5 lbs. of sulphate of ammonia was sown broadcast to the square rod, or worked into the soil very thoroughly in the rows where the seed was to be sown. Superphosphate was applied at the same rate, but instead of sowing it broadcast, I aimed to get it as near the seed or the roots of plants as possible.

Half a teaspoonful of the mixture, consisting of equal parts of superphosphate and sulphate of ammonia, stirred into a large three gallon can of water, and sprinkled on to a bed of verbenas, seemed to have a remarkable effect on the size and brilliancy of the flowers.

Even to this day, although I have a good supply of rich barn-yard-manure, I do not like to be without some good artificial manure for the garden.

MANURE FOR HOT-BEDS.

The best manure for hot-beds is horse or sheep-dung that has been used as bedding for pigs.

When fresh stable-manure is used, great pains should be taken to save all the urine. In other words, you want the horse-dung thoroughly saturated with urine.

The heat is produced principally from the carbon in the manure and straw, but you need active nitrogenous matter to start the fire. And the richer the manure is in nitrogenous matter, and the more thoroughly this is distributed through the manure, the more readily will it ferment. There is also another advantage in having rich manure, or manure well saturated with urine. You can make the heap more compact. Poor manure has to be made in a loose heap, or it will not ferment; but such manure as we are talking about can be trodden down quite firm, and still ferment rapid enough to give out the necessary heat, and this compact heap will continue to ferment longer and give out a steadier heat, than the loose heap of poor manure.

MANURE FOR NURSERYMEN.

Our successful nurserymen purchase large quantities of stable and other manures from the cities, drawing it as fast as it is made, and putting it in piles until wanted. They usually turn the piles once or twice, and often three times. This favors fermentation, greatly reducing it in bulk, and rendering the manure much more soluble and active. It also makes the manure in the heap more uniform in quality.

Messrs. Ellwanger & Barry tell me that they often ferment the manure that they draw from the stables in the city, and make it so fine and rich, that they get but one load of rotted manure from three loads as drawn from the stables. For some crops, they use at least 20 loads of this rotted manure per acre, and they estimate that each load of this rotted manure costs at least $5.00.

H. E. Hooker places the cost of manure equally high, but seems willing to use all he can get, and does not think we can profitably employ artificial manures as a substitute.

In this I agree with him. But while I should not expect artificial manures, when used alone, to prove as cheap or as valuable as stable-manure at present prices, I think it may well be that a little nitrate of soda, sulphate of ammonia, and superphosphate of lime, or dissolved Peruvian guano, might be used as an *auxiliary* manure to great advantage.

Mr. H. E. Hooker, once sowed, at my suggestion, some sulphate of ammonia and superphosphate on part of a block of nursery trees, and he could not perceive that these manures did any good. Ellwanger & Barry also tried them, and reported the same negative result. This was several years ago, and I do not think any similar experiments have been made since.

"And yet," said the Deacon, "you used these self same manures on farm-crops, and they greatly increased the growth."

"There are several reasons," said the Doctor, "why these manures may have failed to produce any marked effect on the nursery trees. In the first place, there was considerable prejudice against them, and the nurserymen would hardly feel like relying on these manures alone. They probably sowed them on land already well manured; and I think they sowed them too late in the season. I should like to see them fairly tried."

So would I. It seems to me that nitrate of soda, and superphosphate, or dissolved Peruvian guano, could be used with very great advantage and profit by the nurserymen. Of course, it would hardly be safe to depend upon them alone. They should be used either in connection with stable-manure, or on land that had previously been frequently dressed with stable-manure.

MANURE FOR FRUIT-GROWERS.

How to keep up the fertility of our apple-orchards, is becoming an important question, and is attracting considerable attention.

There are two methods generally recommended—I dare not say generally practised. The one, is to keep the orchard in bare-fallow; the other, to keep it in grass, and top-dress with manure, and either eat the grass off on the land with sheep and pigs, or else mow it frequently, and let the grass rot on the surface, for mulch and manure.

"You are speaking now," said the Deacon, "of bearing apple-orchards. No one recommends keeping a young orchard in grass. We all know that young apple trees do far better when the land is occupied with corn, potatoes, beans, or some other crop, which can be cultivated, than they do on land occupied with wheat, barley, oats, rye, buckwheat, or grass and clover. And even with bearing peach trees, I have seen a wonderful difference in an orchard, half of which was cultivated with corn, and the other half sown with wheat. The trees in the wheat were sickly-looking, and bore a small crop of inferior fruit, while the trees in the corn, grew vigorously and bore a fine crop of fruit. And the increased value of the crop of peaches on the cultivated land was far more than we can ever hope to get from a crop of wheat."

"And yet," said the Doctor, "the crop of corn on the cultivated half of the peach-orchard removed far more plant-food from the soil, than the crop of wheat. And so it is evident that the difference is not due wholly to the supply of manure in the surface-soil. It may well be that the cultivation which the corn received favored the decomposition of organic matter in the soil, and the formation of nitrates, and when the rain came, it would penetrate deeper into the loose soil than on the adjoining land occupied with wheat. The rain would carry the nitrogen down to the roots of the peach trees, and this will account for the dark green color of the leaves on the cultivated land, and the yellow, sickly-looking leaves on the trees among the wheat.

HEN-MANURE, AND WHAT TO DO WITH IT.

A bushel of corn fed to a hen would give no more nitrogen, phosphoric acid, and potash, in the shape of manure, than a bushel of corn fed to a pig. The manure from the pig, however, taking the urine and solid excrement together, contain 82 per cent of water, while that from the hen contains only 56 per cent of water. Moreover, hens pick up worms and insects, and their food in such case would contain more nitrogen than the usual food of pigs, and the manure would be correspondingly richer in nitrogen. Hence it happens that 100 lbs. of *dry* hen-manure would usually be richer in nitrogen than 100 lbs. of *dry* pig-manure. But feed pigs on peas, and hens on corn, and the dry pig-manure would be much richer in nitrogen than the dry hen-manure. The value of the manure, other things being equal, depends on the food and not on the animal.

Let no man think he is going to make his farm any richer by keeping hens, ducks, and geese, than he will by keeping sheep, pigs, and horses.

"Why is it, then," asked the Deacon, "that hen-dung proves such a valuable manure. I would rather have a hundred lbs. of hen-dung than half a ton of barnyard-manure?"

"And I presume you are right," said I, "but you must recollect that your hen-manure is kept until it is almost chemically dry. Let us figure up what the half ton of manure and the 100 lbs. of hen-manure would contain. Here are the figures, side by side:

	100 *lbs. dry Hen-Manure.*	*Half ton Cow-Dung with straw.*
Water (estimated)	12 lbs.	775 lbs.
Organic Matter	51 "	203 "
Ash	37 "	22 "
Nitrogen	3¼ "	3²/₅ "
Potash	1¾ "	4 "
Lime	4¾ "	3 "
Phosphoric acid	3 "	1½ "

I would, myself, far rather have 100 lbs. of your dry hen-manure than half a ton of your farmyard-manure. Your hens are fed on richer food than your cows. The 100 lbs. of hen-manure, too, would act much more rapidly than the half ton of cow-manure. It would probably do twice as much good—possibly three or four times as much good, on the first crop, as the cow-manure. The nitrogen, being obtained from richer and more digestible food, is in a much more active and available condition than the nitrogen in the cow-dung.

"If you go on," said the Deacon, "I think you will prove that I am right."

"I have never doubted," said I, "the great value of hen-dung, as compared with barnyard-manure. And all I wish to show is, that, notwithstanding its acknowledged value, the fact remains that a given quantity of the same kind of food will give no greater amount of fertilizing matter when fed to a hen than if fed to a pig."

I want those farmers who find so much benefit from an application of hen-manure, ashes, and plaster, to their corn and potatoes, to feel that if they would keep better cows, sheep, and pigs, and feed them better, they would get good pay for their feed, and the manure would enable them to grow larger crops.

While we have been talking, the Deacon was looking over the tables. (See Appendix.) "I see," said he, "that wheat and rye contain more nitrogen than hen-manure, but less potash and phosphoric acid."

"This is true," said I, "but the way to compare them, in order to see the effect of passing the wheat through the hen, is to look at the composition of the air-dried hen-dung. The fresh hen-dung, according to the table, contains 56 per cent of water, while wheat contains less than 14½ per cent."

Let us compare the composition of 1,000 lbs. air-dried hen-dung with 1,000 lbs. of air-dried wheat and rye, and also with bran, malt-combs, etc.

	Nitrogen.	Potash.	Phosphoric Acid.
Wheat	20.8	5.3	7.9
Wheat Bran	22.4	14.3	27.3
Rye	17.6	5.6	8.4
Rye Bran	23.2	19.3	34.3
Buckwheat	14.4	2.7	5.7
Buckwheat Bran	27.2	11.2	12.5
Malt-roots	36.8	20.6	18.0
Air-dry Hen-dung	32.6	17.0	30.8

"That table," said the Doctor, "is well worth studying. You see, that when wheat is put through the process of milling, the miller takes out as much of the starch and gluten as he wants, and leaves you a product (bran), richer in phosphoric acid, potash, and nitrogen, than you gave him."

"And the same is true," continued the Doctor, "of the hen. You gave her 2,000 grains of wheat, containing 41.6 grains of nitrogen. She puts this through the mill, together with some ashes, and bones, that she picks up, and she takes out all the starch and fat, and nitrogen, and phosphate of lime, that she needs to sustain life, and to produce flesh, bones, feathers, and eggs, and leaves you 1,000 grains of manure containing 32.6 grains of nitrogen, 17.0 grains of potash, and 30.8 grains of phosphoric acid. I do not say," continued the Doctor, "that it takes exactly 2,000 grains of wheat to make 1,000 grains of dry manure. I merely give these figures to enable the Deacon to understand why 1,000 lbs. of hen-dung is worth more for manure than 1,000 lbs. of wheat."

"I must admit," said the Deacon, "that I always have been troubled to understand why wheat-bran was worth more for manure than the wheat itself. I see now—it is because there is less of it. It is for the same reason that boiled cider is richer than the cider from which it is made. The cider has lost water, and the bran has lost starch. What is left is richer in nitrogen, and potash, and phosphoric acid. And so it is with manure. The animals take out of the food the starch and fat, and leave the manure richer in nitrogen, phosphoric acid, and potash."

"Exactly," said I, "Mr. Lawes found by actual experiment, that if you feed 500 lbs. of barley-meal to a pig, containing 420 lbs. of *dry substance*, you get only 70 lbs. of dry substance in the manure. Of the 420 lbs. of dry substance, 276.2 lbs. are used to support respiration, etc.; 73.8 lbs. are found in the increase of the pig, and 70 lbs. in the manure."

The food contains 52 lbs. of nitrogenous matter; the increase of pig contains 7 lbs., and consequently, if there is no loss, the manure should contain 45 lbs. of nitrogenous substance=to 7.14 lbs. of nitrogen.

"In other words," said the Doctor, "the 70 lbs. of *dry* liquid and solid pig-manure contains 7.14 lbs. of nitrogen, or 100 lbs. would contain 10.2 lbs. of nitrogen, which is more nitrogen than we now get in the very best samples of Peruvian guano."

"And thus it will be seen," said I, "that though corn-fed pigs, leaving out the bedding and water, produce a very small quantity of manure, it is exceedingly rich."

The table from which these facts were obtained, will be found in the Appendix—pages 342–3.

CHAPTER XXXVI.

DIFFERENT KINDS OF MANURE.

COW-MANURE, AND HOW TO USE IT.

"It will do more good if fermented," said a German farmer in the neighborhood, who is noted for raising good crops of cabbage, "but I like hog-manure better than cow-dung. The right way is to mix the hog-manure, cow-dung, and horse-manure together."

"No doubt about that," said I, "but when you have a good many cows, and few other animals, how would you manage the manure?"

"I would gather leaves and swamp-muck, and use them for bedding the cows and pigs. Leaves make splendid bedding, and they make rich manure, and the cow-dung and leaves, when made into a pile, will ferment readily, and make grand manure for—anything. I only wish I had all I could use."

There is no question but what cow-manure is better if fermented, but it is not always convenient to pile it during the winter in such a way that it will not freeze. And in this case it may be the better plan to draw it out on to the land, as opportunity offers.

"I have heard," said Charley, "that pig-manure was not good for cabbage, it produces 'fingers and toes,' or club-foot."

Possibly such is the case when there is a predisposition to the disease, but our German friend says he has never found any ill-effects from its use.

"Cows," said the Doctor, "when giving a large quantity of milk, make rather poor manure. The manure loses what the milk takes from the food."

"We have shown what that loss is," said I. "It amounts to less than I think is generally supposed. And in the winter, when the cows are dry, the manure would be as rich as from oxen, provided both were fed alike. See Appendix, page 342. It will there be seen that oxen take out only 4.1 lbs. of nitrogen from 100 lbs. of nitrogen consumed in the food. In other words, provided there is no loss, we should get in the liquid and solid excrements of the ox and dry cow 95.9 per cent. of the nitrogen furnished in the food, and a still higher per cent of the mineral matter.

SHEEP-MANURE.

According to Prof. Wolff's table of analyses, sheep-manure, both solid and liquid, contain less water than the manure from horses, cows, or swine. With the exception of swine, the solid dung is also the richest in nitrogen, while the urine of sheep is pre-eminently rich in nitrogen and potash.

These facts are in accordance with the general opinions of farmers. Sheep-manure is considered, next to hen-manure, the most valuable manure made on the farm.

I do not think we have any satisfactory evidence to prove that 3 tons of clover-hay and a ton of corn fed to a lot of fattening-sheep will afford a quantity of manure containing any more plant-food than the same kind and amount of food fed to a lot of fattening-cattle. The experiments of Lawes & Gilbert indicate that if there is any difference it is in favor of the ox. See Appendix, page 343. But it may well be that it is much easier to save the manure from the sheep than from the cattle. And so, practically, sheep may be better manure-makers than cattle—for the simple reason that less of the urine is lost.

"As a rule," said the Doctor, "the dung of sheep contains far less water than the dung of cattle, though when you slop your breeding ewes to make them give more milk, the dung differs but little in appearance from that of cows. Ordinarily, however, sheep-dung is light and dry, and, like horse-dung, will ferment much more rapidly than cow or pig-dung. In piling manure in the winter or spring, special pains should be used to mix the sheep and horse-manure with the cow and pig-manure. And it may be remarked that for any crop or for any purpose where stable-manure is deemed desirable, sheep-manure would be a better substitute than cow or pig-manure."

MANURE FROM SWINE.

The dry matter of hog-manure, especially the urine, is rich in nitrogen, but it is mixed with such a large quantity of water that a ton of hog-manure, as it is usually found in the pen, is less valuable than a ton of horse or sheep-manure, and only a little more valuable than a ton of cow-manure.

As I have before said, my own plan is to let the store-hogs sleep in a basement-cellar, and bed them with horse and sheep-manure. I have this winter over 50 sows under the horse-stable, and the manure from 8 horses keeps them dry and comfortable, and we are not specially lavish with straw in bedding the horses.

During the summer we aim to keep the hogs out in the pastures and orchards as much as possible. This is not only good for the health of the pigs, but saves labor and straw in the management of the manure. It goes directly to the land. The pigs are good grazers and distribute the manure as evenly over the land as sheep—in fact, during hot weather, sheep are even more inclined to huddle together under the trees, and by the side of the fence, than pigs. This is particularly the case with the larger breeds of sheep.

In the winter it is not a difficult matter to save all the liquid and solid excrements from pigs, provided the pens are dry and no water comes in from the rain and snow. As pigs are often managed, this is the real difficulty. Pigs void an enormous quantity of water, especially when fed on slops from the house, whey, etc. If they are kept in a pen with a separate feeding and sleeping apartment, both should be under cover, and the feeding apartment may be kept covered a foot or so thick with the soiled bedding from the sleeping apartment. When the pigs get up in a morning, they will go into the feeding apartment, and the liquid will be discharged on the mass of manure, straw, etc.

"Dried muck," said the Deacon, "comes in very handy about a pig-pen, for absorbing the liquid."

"Yes," said I, "and even dry earth can be used to great advantage, not merely to absorb the liquid, but to keep the pens sweet and healthy. The three chief points in saving manure from pigs are: 1, To have the pens under cover; 2, to keep the feeding apartment or yard covered with a thick mass of strawy manure and refuse of any kind, and 3, to scatter plenty of dry earth or dry muck on the floor of the sleeping apartment, and on top of the manure in the feeding apartment."

"You feed most of your pigs," said the Deacon, "out of doors in the yard, and they sleep in the pens or basement cellars, and it seems to me to be a good plan, as they get more fresh air and exercise than if confined."

"We do not lose much manure," said I, "by feeding in the yards. You let a dozen pigs sleep in a pen all night, and as soon as they hear you putting the food in the troughs outside, they come to the door of the pen, and there discharge the liquid and solid excrements on the mass of manure left there on purpose to receive and absorb them. I am well aware that as pigs are often managed, we lose at least half the value of their manure, but there is no necessity for this. A little care and thought will save nearly the whole of it.

BUYING MANURE BY MEASURE OR WEIGHT.

The Deacon and I have just been weighing a bushel of different kinds of manure made on the farm. We made two weighings of each kind, one thrown in loose, and the other pressed down firm. The following is the result:

WEIGHT OF MANURE PER BUSHEL, AND PER LOAD OF 50 BUSHELS.

No.	KIND AND CONDITION OF MANURES.	Weight ℔ Bushel in lbs.	Weight ℔ Load of 50 bushels.
		lbs.	lbs.
1.	Fresh horse-manure free from straw	37½	1875
2.	" " " " " " pressed	55	2750
3.	Fresh horse-manure, as used for bedding pigs	28	1400
4.	" " " " " " pressed	46	2300
5.	Horse-manure from pig cellar	50	2500
6.	" " " " " pressed	72	3600
7.	Pig-manure	57	2850
8.	" " pressed	75	3750
9.	Pig-manure and dry earth	98	4900
10.	Sheep-manure from open shed	42	2100
11.	" " " " " pressed	65	3250
12.	Sheep-manure from closed shed	28	1400
13.	" " " " " pressed	38	1900
14.	Fresh cow-dung, free from straw	87	4350
15.	Hen-manure	34	1700
16.	" " pressed	48	2400

"In buying manure," said the Deacon, "it makes quite a difference whether the load is trod down solid or thrown loosely into the box. A load of fresh horse-manure, when trod down, weighs half as much again as when thrown in loose."

"A load of horse-manure," said Charley, "after it has been used for bedding pigs, weighs 3,600 lbs., and only 2,300 lbs. when it is thrown into the pens, and I suppose a ton of the 'double-worked' manure is fully as valuable as a ton of the fresh horse-manure. If so, 15 'loads' of the pig-pen manure is equal to 24 'loads' of the stable-manure."

"A ton of fresh horse-manure," said the Doctor, "contains about 9 lbs. of nitrogen; a ton of fresh cow-dung about 6 lbs.; a ton of fresh sheep-dung, 11 lbs., and a ton of fresh pig-manure, 12 lbs. But if the Deacon and you weighed correctly, a 'load' or cord of cow-manure would contain more nitrogen than a load of pressed horse-manure. The figures are as follows:

A load of 50 bushels of fresh horse-dung, pressed and free from straw contains	12.37 lbs.	nitrogen.
A load of fresh cow-dung	13.05 "	"
" " sheep "	10.45 "	"
" " pig "	22.50 "	"

"These figures," said I, "show how necessary it is to look at this subject in all its aspects. If I was buying manures *by weight*, I would much prefer a ton of sheep-manure, if it had been made under cover, to any other manure except hen-dung, especially if it contained all the urine from the sheep. But if buying manure by the load or cord, that from a covered pig-pen would be preferable to any other."

LIQUID MANURE ON THE FARM.

I have never had any personal experience in the use of liquid manure to any crop except grass. At Rothamsted, Mr. Lawes used to draw out the liquid manure in a water-cart, and distribute it on grass land.

"What we want to know," said the Deacon, "is whether the liquid from our barn-yards will pay to draw out. If it will, the proper method of using it can be left to our ingenuity."

According to Prof. Wolff, a ton of urine from horses, cows, sheep, and swine, contains the following amounts of nitrogen, phosphoric acid, and potash, and, for the sake of comparison, I give the composition of drainage from the barn-yard, and also of fresh dung of the different animals:

TABLE SHOWING THE AMOUNT OF NITROGEN, PHOSPHORIC ACID, AND POTASH, IN ONE TON OF THE FRESH DUNG AND FRESH URINE OF DIFFERENT ANIMALS, AND ALSO OF THE DRAINAGE OF THE BARN-YARD.

	1 TON FRESH DUNG.			1 TON FRESH URINE.		
	Nitrogen.	*Phosphoric acid.*	*Potash.*	*Nitrogen.*	*Phosphoric acid.*	*Potash.*
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Horse	8.8	7.0	7.0	31.0		30.0
Cow	5.8	3 4	2.0	11.6		9.8
Sheep	11.0	6.2	3.0	39.0	0.2	45.2
Swine	12.0	8.2	5.2	8.6	1.4	16.6
Mean	9.4	6.2	4.3	22.5	0.4	25.4
Drainage of barn-yard				3.0	0.2	9.8

The drainage from a barn-yard, it will be seen, contains a little more than half as much nitrogen as cow-dung; and it is probable that the nitrogen in the liquid is in a much more available condition than that in the dung. It contains, also, nearly five times as much potash as the dung. It would seem, therefore, that with proper arrangements for pumping and distributing, this liquid could be drawn a short distance with profit.

But whether it will or will not pay to cart away the drainage, it is obviously to our interest to prevent, as far as possible, any of the liquid from running to waste.

It is of still greater importance to guard against any loss of urine. It will be seen that, on the average, a ton of the urine of our domestic animals contains more than twice as much nitrogen as a ton of the dung.

Where straw, leaves, swamp-muck, or other absorbent materials are not sufficiently abundant to prevent any loss of urine, means should be used to drain it into a tank so located that the liquid can either be pumped back on to the manure when needed, or drawn away to the land.

"I do not see," said the Deacon, "why horse and sheep-urine should contain so much more nitrogen and potash than that from the cow and pig."

"The figures given by Prof. Wolff," said I, "are general averages. The composition of the urine varies greatly. The richer the food in digestible nitrogenous matter, the more nitrogen will there be in the dry matter of the urine. And, other things being equal, the less water the animal drinks, the richer will the urine be in nitrogen. The urine from a sheep fed solely on turnips would contain little or no more nitrogen than the urine of a cow fed on turnips. An ox or a dry cow fed on grass would probably void no more nor no poorer urine than a horse fed on grass. The urine that Mr. Lawes drew out in a cart on to his grass-land was made by sheep that had one ℔. each of oil-cake per day, and one ℔. of chaffed clover-hay, and all the turnips they would eat. They voided a large quantity of urine, but as the food was rich in nitrogen, the urine was doubtless nearly or quite as rich as that analyzed by Prof. Wolff, though that probably contained less water.

If I was going to draw out liquid manure, I should be very careful to spout all the buildings, and keep the animals and manure as much under cover as possible, and also feed food rich in nitrogen. In such circumstances, it would doubtless pay to draw the urine full as well as to draw the solid manure.

NIGHTSOIL AND SEWAGE.

The composition of human excrements, as compared with the mean composition of the excrements from horses, cows, sheep, and swine, so far as the nitrogen, phosphoric acid, and potash are concerned, is as follows:

TABLE SHOWING THE AMOUNT OF NITROGEN, PHOSPHORIC ACID, AND POTASH, IN ONE TON OF FRESH HUMAN EXCREMENTS, AND IN ONE TON OF FRESH EXCREMENTS FROM HORSES, COWS, SHEEP, AND SWINE.

One ton (2000 lbs).	SOLIDS.			URINE.		
	Nitrogen.	*Phosphoric acid.*	*Potash.*	*Nitrogen.*	*Phosphoric acid.*	*Potash.*
Human	20.0 lbs.	21.8 lbs.	5.0 lbs.	12.0 lbs.	3.7 lbs.	4.0 lbs.
Mean of horse, cow, sheep, and swine....	9.4 "	6.2 "	4.3 "	22.5 "	0.4 "	25.4 "

One ton of fresh fæces contains more than twice as much nitrogen, and more than three times as much phosphoric acid, as a ton of fresh mixed animal-dung. The nitrogen, too, is probably in a more available condition than that in common barnyard-dung; and we should not be far wrong in estimating 1 ton of fæces equal to 2½ tons of ordinary dung, or about equal in value to carefully preserved manure from liberally-fed sheep, swine, and fattening cattle.

"It is an unpleasant job," said the Deacon, "but it pays well to empty the vaults at least twice a year."

"If farmers," said the Doctor, "would only throw into the vaults from time to time some dry earth or coal ashes, the contents of the vaults could be removed without any disagreeable smell."

"That is so," said I, "and even where a vault has been shamefully neglected, and is full of offensive matter, it can be cleaned out without difficulty and without smell. I have cleaned out a large vault in an hour. We were drawing manure from the yards with three teams and piling it in the field. We brought back a load of sand and threw half of it into the vault, and put the other half on one side, to be used as required. The sand and fæces were then, with a long-handled shovel, thrown into the wagon, and drawn to the pile of manure in the field, and thrown on to the pile, not more than two or three inches thick. The team brought back a load of sand, and so we continued until the work was done. Sand or dry earth is cheap, and we used all that was necessary to prevent the escape of any unpleasant gases, and to keep the material from adhering to the shovels or the wagon.

"Human urine," said the Doctor, "is richer in phosphoric acid, but much poorer in nitrogen and potash than the urine from horses, cows, sheep, and swine."

"Some years ago," said the Deacon, "Mr. H. E. Hooker, of Rochester, used to draw considerable quantities of urine from the city to his farm. It would pay better to draw out the urine from farm animals."

"The figures given above," said I, "showing the composition of human excrements, are from Prof. Wolff, and probably are generally correct. But, of course, the composition of the excrements would vary greatly, according to the food."

It has been ascertained by Lawes and Gilbert that the amount of matter voided by an adult male in the course of a year is—fæces, 95 lbs.; urine, 1,049 lbs.; total liquid and solid excrements in the pure state, 1,144 lbs. These contain:

Dry substance—fæces, 23¾ lbs.; urine, 34½; total, 58¼ lbs.
Mineral matter—fæces, 2½ lbs.; urine, 12; total, 14½ lbs.
Carbon—fæces, 10 lbs.; urine, 12; total 22 lbs.
Nitrogen—fæces, 1.2 lbs.; urine, 10.8; total, 12 lbs.
Phosphoric acid—fæces, 0.7 lbs.; urine, 1.93; total, 2.63 lbs.
Potash—fæces, 0.24 lbs.; urine, 2.01; total, 2.25 lbs.

The amount of potash is given by Prof. E. Wolff, not by Lawes and Gilbert.

The mixed solid and liquid excrements, in the condition they leave the body, contain about 95 per cent of water. It would require, therefore, 20 tons of fresh mixed excrements, to make one ton of *dry* nightsoil, or the entire amount voided by a mixed family of 43 persons in a year.

One hundred lbs. of fresh fæces contain 75 lbs. of water, and 25 lbs. of dry substance.

One hundred lbs. of fresh urine contain 96½ lbs. of water, and 3½ lbs. of dry substance.

One hundred lbs. of the dry substance of the fæces contain 5 lbs. of nitrogen, and 5½ lbs. of phosphates.

One hundred lbs. of the dry substance of the urine contain 27 lbs. of nitrogen, and 10¾ lbs. of phosphates.

These figures are from Lawes and Gilbert, and may be taken as representing the composition of excrements from moderately well-fed persons.

According to Wolff, a ton of fresh human urine contains 12 lbs. of nitrogen. According to Lawes and Gilbert, 18 lbs.

The liquid carted from the city by Mr. Hooker was from well-fed adult males, and would doubtless be fully equal to the figures given by Lawes and Gilbert. If we call the nitrogen worth 20 cents a lb., and the phosphoric acid (soluble) worth 12½ cents, a ton of such urine would be worth, *on the land*, $4.06.

"A ton of the fresh fæces," said the Deacon, "at the same estimate, would be worth (20 lbs. nitrogen, at 20 cents, $4; 21¾ lbs. phosphoric acid, at 12½ cents, $2.70), $6.70."

"Not by a good deal," said the Doctor. "The nitrogen and phosphoric acid in the urine are both soluble, and would be immediately available. But the nitrogen and phosphoric acid in the fæces would be mostly insoluble. We cannot estimate the nitrogen in the fæces at over 15 cents a lb., and the phosphoric acid at 5 cents. This would make the value of a ton of fresh fæces, *on the land*, $4.09."

"This makes the ton of fæces worth about the same as a ton of urine. But I would like to know," said the Deacon, "if you really believe we could afford to pay $4 per ton for the stuff delivered on the farm?"

"If we could get the genuine article," said the Doctor, "it would be worth $4 a ton. But, as a rule, it is mixed with water, and dirt, and stones, and bricks, and rubbish of all kinds. Still, it is unquestionably a valuable fertilizer."

"In the dry-earth closets," said I, "such a large quantity of earth has to be used to absorb the liquid, that the material, even if used several times, is not worth carting any considerable distance. Dr. Gilbert found that 5 tons of absolutely dry earth, before using, contained 16.7 lbs. of nitrogen.

After being used *once*, ...	5 tons of the dry earth contained	24.0 lbs.
" " " twice, ...	" " " " " "	36.3 "
" " " three times,.	" " " " " "	44.6 "
" " " four times,..	" " " " " "	54.0 "
" " " five times,..	" " " " " "	61.4 "
" " " six times,....	" " " " " "	71.6 "

Dr. Vœlcker found that five tons of dry earth gained about 7 lbs. of nitrogen, and 11 lbs. of phosphoric acid, each time it was used in the closets. If we consider each lb. of nitrogen with the phosphoric acid worth 20 cents a lb., 5 tons of the dry earth, after being used once, would be worth $1.46, or less than 30 cents a ton, and after it had been used six times, five tons of the material would be worth $11.98, or about $2.40 per ton.

In this calculation I have not reckoned in the value of the nitrogen the soil contained before using. Soil, on a farm, is cheap.

It is clear from these facts that any earth-closet manure a farmer would be likely to purchase in the city has not a very high value. It is absurd to talk of making "guano" or any concentrated fertilizer out of the material from earth-closets.

"It is rather a reflection on our science and practical skill," said the Doctor, "but it looks at present as though the only plan to adopt in large cities is to use enormous quantities of water and wash the stuff into the rivers and oceans for the use of aquatic plants and fishes. The nitrogen is not all lost. Some of it comes back to us in rains and dews. Of course, there are places where the sewage of our cities and villages can be used for irrigating purposes. But when water is used as freely as it ought to be used for health, the sewage is so extremely poor in fertilizing matter, that it must be used in enormous quantities, to furnish a dressing equal to an application of 20 tons of stable-manure per acre."

"If," continued the Doctor, "the sewage is used merely as *water* for irrigating purposes, that is another question. The water itself may often be of great benefit. This aspect of the question has not received the attention it merits."

PERUVIAN GUANO.

Guano is the manure of birds that live principally on fish.

Fish contain a high percentage of nitrogen and phosphoric acid, and consequently when fish are digested and the carbon is burnt out of them, the manure that is left contains a still higher percentage of nitrogen and phosphoric acid than the fish from which it was derived.

Guano is digested fish. If the guano, or the manure from the birds living on fish, has been preserved without loss, it would contain not only a far higher percentage of nitrogen, but the nitrogen would be in a much more available condition, and consequently be more valuable than the fish from which the guano is made.

The difference in the value of guano is largely due to a difference in the climate and locality in which it is deposited by the birds. In a rainless and hot climate, where the bird-droppings would dry rapidly, little or no putrefaction or fermentation would take place, and there would be no loss of nitrogen from the formation and escape of ammonia.

In a damper climate, or where there was more or less rain, the bird-droppings would putrefy, and the ammonia would be liable to evaporate, or to be leached out by the rain.

Thirty years ago I saw a quantity of Peruvian guano that contained more than 18 per cent of nitrogen. It was remarkably light colored. You know that the white part of hen-droppings consists principally of uric acid, which contains about 33 per cent of nitrogen.

For many years it was not difficult to find guano containing 13 per cent of nitrogen, and genuine Peruvian guano was the cheapest and best source of available nitrogen. But latterly, not only has the price been advanced, but the quality of the guano has deteriorated. It has contained less nitrogen and more phosphoric acid. See the Chapter on "Value of Fertilizers," Page 324.

SALTS OF AMMONIA AND NITRATE OF SODA.

"I wish," said the Deacon, "you would tell us something about the 'ammonia-salts' and nitrate of soda so long used in Lawes and Gilbert's experiments. I have never seen any of them."

"You could not invest a little money to better advantage than to send for a few bags of sulphate of ammonia and nitrate of soda. You would then see what they are, and would learn more by using them, than I can tell you in a month. You use them just as you would common salt. As a rule, the better plan is to sow them broadcast, and it is important to distribute them evenly. In sowing common salt, if you drop a handful in a place, it will kill the plants. And so it is with nitrate of soda or sulphate of ammonia. Two or three pounds on a square rod will do good, but if you put half of it on a square yard, it will burn up the crop, and the other half will be applied in such a small quantity that you will see but little effect, and will conclude that it is a humbug. Judging from over thirty years' experience, I am safe in saying that not one man in ten can be trusted to sow these manures. They should be sown with as much care as you sow grass or clover-seed."

"The best plan," said the Doctor, "is to mix them with sifted coal-ashes, or with gypsum, or sifted earth."

"Perhaps so," said I, "though there is nothing gained by mixing earth or ashes with them, except in securing a more even distribution. And if I was going to sow them myself, I would much prefer sowing them unmixed. Any man who can sow wheat or barley can sow sulphate of ammonia or nitrate of soda."

"Lawes and Gilbert," said the Deacon, "used sulphate and muriate of ammonia, and in one or two instances the carbonate of ammonia. Which is the best?"

"The one that will furnish ammonia or nitrogen at the cheapest rate," said the Doctor, "is the best to use. The muriate of ammonia contains the most ammonia, but the sulphate, in proportion to the ammonia, is cheaper than the muriate, and far cheaper than the carbonate.

Carbonate of ammonia contains $21\frac{1}{2}$ per cent of ammonia.

Sulphate of ammonia contains $25\frac{3}{4}$ per cent of ammonia$=21^1/_5$ of nitrogen.

Muriate of ammonia contains 31 per cent of ammonia=25½ of nitrogen.

Nitrate of soda contains $16^2/_5$ per cent of nitrogen.

Nitrate of potash, 13⅘ per cent of nitrogen.

From these figures you can ascertain, when you know the price of each, which is the cheapest source of nitrogen.

"True," said I, "but it must be understood that these figures represent the composition of a pure article. The commercial sulphate of ammonia, and nitrate of soda, would usually contain 10 per cent of impurities. Lawes and Gilbert, who have certainly had much experience, and doubtless get the best commercial articles, state that a mixture of equal parts sulphate and muriate of ammonia contains about 25 per cent of ammonia. According to the figures given by the Doctor, the mixture would contain, if pure, over 28 per cent of ammonia. In other words, 90 lbs. of the pure article contains as much as 100 lbs. of the commercial article."

As to whether it is better, when you can buy nitrogen at the same price in nitrate of soda as you can in sulphate of ammonia, to use the one or the other will depend on circumstances. The nitrogen exists as nitric acid in the nitrate of soda, and as ammonia in the sulphate of ammonia. But there are good reasons to believe that before ammonia is used by the plants it is converted into nitric acid. If, therefore, we could apply the nitrate just where it is wanted by the growing crop, and when there is rain enough to thoroughly distribute it through the soil to the depth of six or eight inches, there can be little doubt that the nitrate, in proportion to the nitrogen, would have a quicker and better effect than the sulphate of ammonia.

"There is another point to be considered," said the Doctor. "Nitric acid is much more easily washed out of the soil than ammonia. More or less of the ammonia enters into chemical combination with portions of the soil, and may be retained for months or years."

When we use nitrate of soda, we run the risk of losing more or less of it from leaching, while if we use ammonia, we lose, for the time being, more or less of it from its becoming locked up in insoluble combinations in the soil. For spring crops, such as barley or oats, or spring wheat, or for a meadow or lawn, or for top-dressing winter-wheat in the spring, the nitrate of soda, provided it is sown early enough, or at any time in the spring, just previous to a heavy rain, is likely to produce a better effect than the sulphate of ammonia. But for sowing in the autumn on winter-wheat the ammonia is to be preferred.

"Saltpetre, or nitrate of potash," said the Deacon, "does not contain as much nitrogen as nitrate of soda."

"And yet," said the Doctor, "if it could be purchased at the same price, it would be the cheaper manure. It contains 46½ per cent of potash, and on soils, or for crops where potash is needed, we may sometimes be able to purchase saltpetre to advantage."

"If I could come across a lot of damaged saltpetre," said I, "that could be got for what it is worth as manure, I should like to try it on my apple trees—one row with nitrate of soda, and one row with nitrate of potash. When we apply manure to apple trees, the ammonia, phosphoric acid, and potash, are largely retained in the first few inches of surface-soil, and the deeper roots get hold of only those portions which leach through the upper layer of earth. Nitric acid, however, is easily washed down into the subsoil, and would soon reach all the roots of the trees."

CHAPTER XXXVII.

BONE-DUST AND SUPERPHOSPHATE OF LIME.

Bone-dust is often spoken of as a phosphatic manure, and it has been supposed that the astonishing effect bone-dust sometimes produces on old pasture-land, is due to its furnishing phosphoric acid to the soil.

But it must be remembered that bone-dust furnishes nitrogen as well as phosphoric acid, and we are not warranted in ascribing the good effect of bones to phosphoric acid alone.

Bones differ considerably in composition. They consist essentially of gelatine and phosphate of lime. Bones from young animals, and the soft porous parts of all bones, contain more gelatine than the solid parts, or the bones from older animals. On the average, 1,000 lbs. of good commercial bone-dust contains 38 lbs. of nitrogen.

On the old dairy farms of Cheshire, where bone-dust produced such marked improvement in the quantity and quality of the pastures and meadows, it was usual to apply from 4,000 to 5,000 lbs. per acre, and often more. In other words, a dressing of bone-dust frequently contained 200 lbs. of nitrogen per acre—equal to 20 or 25 tons of barn-yard manure.

"It has been supposed," said the Doctor, "that owing to the removal of so much phosphoric acid in the cheese sold from the farm, that the dairy pastures of Cheshire had been exhausted of phosphoric acid, and that the wonderful benefits following an application of bone-dust to these pastures, was due to its supplying phosphoric acid."

"I do not doubt," said I, "the value of phosphoric acid when applied in connection with nitrogen to old pasture lands, but I contend that the experience of the Cheshire dairymen with bone-dust is no positive proof that their soils were particularly deficient in phosphoric acid. There are many instances given where the gelatine of the bones, alone, proved of great value to the grass. And I think it will be found that the Cheshire dairymen do not find as much benefit from superphosphate as they did from bone-dust. And the reason is, that the latter, in addition to the phosphoric acid, furnished a liberal dressing of nitrogen. Futhermore, it is not true that dairying specially robs the soil of phosphoric acid. Take one of these old dairy farms in Cheshire, where a dressing of bone-dust, according to a writer in the Journal of the Royal Agricultural Society, has caused 'a miserable covering of pink grass, rushes, and a variety of other noxious weeds, to give place to the most luxuriant herbage of wild clover, trefoil, and other succulent and nutritious grasses.' It is evident from this description of the pastures before the bones were used, that it would take at least three acres to keep a cow for a year.

"I have known," says the same writer quoted above, "many a poor, honest, but half broken-hearted man raised from poverty to comparative independence, and many a sinking family saved from inevitable ruin by the help of this wonderful manure." And this writer not only spoke from observation and experience, but he showed his faith by his works, for he tells us that he had paid nearly $50,000 for this manure.

Now, on one of these poor dairy farms, where it required 3 acres to keep a cow, and where the grass was of poor quality, it is not probable that the cows produced over 250 lbs. of cheese in a year. One thousand pounds of cheese contains, on the average, about 45½ lbs. of nitrogen; 2½ lbs. of potash, and 11½ lbs. of phosphoric acid. From this it follows, if 250 lbs. of cheese are sold annually from three acres of pasture, less than one lb. of phosphoric acid per acre is exported from the farm in the cheese.

One ton of timothy-hay contains nearly 14½ lbs. of phosphoric acid. And so a farmer who raises a ton of timothy-hay per acre, and sells it, sends off as much phosphoric acid in one year as such a Cheshire dairyman as I have alluded to did in fourteen years.

What the dairymen want, and what farmers generally want, is nitrogen *and* phosphoric acid. Bone-dust furnishes both, and this was the reason of its wonderful effects.

It does not follow from this, that bone-dust is the cheapest and best manure we can use. It is an old and popular manure, and usually commands a good price. It sells for all it is worth. A dozen years ago, I bought ten tons of bone-dust at $18 per ton. I have offered $25 per ton since for a similar lot, but the manufacturers find a market in New York for all they can make.

Bone-dust, besides nitrogen, contains about 23 per cent of phosphoric acid.

"That does not give me," said the Deacon, "any idea of its value."

"Let us put it in another shape, then," said I. "One ton of good bone-dust contains about as much nitrogen as 8½ tons of fresh stable-manure, and as much phosphoric acid as 110 tons of fresh stable-manure. But one ton of manure contains more potash than 5 tons of bone-dust.

Bone-dust, like barnyard-manure, does not immediately yield up its nitrogen and phosphoric acid to plants. The bone phosphate of lime is insoluble in water, and but very slightly soluble in water containing carbonic acid. The gelatine of the bones would soon decompose in a moist, porous, warm soil, provided it was not protected by the oil and by the hard matter of the bones. Steaming, by removing the oil, removes one of the hindrances to decomposition. Reducing the bones as fine as possible is another means of increasing their availability.

Another good method of increasing the availability of bone-dust is to mix it with barnyard-manure, and let both ferment together in a heap. I am inclined to think this the best, simplest, and most economical method of rendering bone-dust available. The bone-dust causes the heap of manure to ferment more readily, and the fermentation of the manure softens the bones. Both the manure and the bones are improved and rendered richer and more available by the process.

Another method of increasing the availability of bone-dust is by mixing it with sulphuric acid.

The phosphate of lime in bones is insoluble in water, though rain water containing carbonic acid, and the water in soils, slowly dissolve it. By treating the bones with sulphuric acid, the phosphate of lime is decomposed and rendered soluble. Consequently, bone-dust treated with sulphuric acid will act much more rapidly than ordinary bone-dust. The sulphuric acid does not make it any *richer* in phosphoric acid or nitrogen. It simply renders them more available.

"And yet," said the Doctor, "the use of sulphuric acid for 'dissolving' bones, or rather phosphate of lime, introduced a new era in agriculture. It is the grand agricultural fact of the nineteenth century."

"It is perhaps not necessary," said I, "to give any direction for treating bones with sulphuric acid. We have got beyond that. We can now buy superphosphate cheaper than we can make it from bones."

"But is it as good?" asked the Deacon.

"Soluble phosphate of lime," said I, "is soluble phosphate of lime, and it makes no difference whether it is made from burnt bones, or from phosphatic guano, or mineral phosphate. That question has been fully decided by the most satisfactory experiments."

"Before you and the Deacon discuss that subject," said the Doctor, "it would be well to tell Charley what superphosphate is."

"I wish you would tell me," said Charley.

"Well," said the Doctor, "phosphate of lime, as it exists in bones, is composed of three atoms of lime and one atom of phosphoric acid. Chemists call it the tricalcic phosphate. It is also called the basic phosphate of lime, and not unfrequently the 'bone-earth phosphate.' It is the ordinary or common form of phosphate of lime, as it exists in animals, and plants, and in the various forms of mineral phosphates.

"Then there is another phosphate of lime, called the dicalcic phosphate, or neutral phosphate of lime, or reverted phosphate of lime. It is composed of one atom of water, two atoms of lime, and one atom of phosphoric acid.

"Then we have what we call superphosphate, or acid phosphate of lime, or more properly monocalcic phosphate. It is composed of two atoms of water, one atom of lime, and one atom of phosphoric acid. This acid phosphate of lime *is soluble in water.*

"The manufacture of superphosphate of lime is based on these facts. The *one-lime* phosphate is soluble, the *three*-lime phosphate is insoluble. To convert the latter into the former, all we have to do is to *take away two atoms of lime.*

"Sulphuric acid has a stronger affinity for lime than phosphoric acid. And when you mix enough sulphuric acid with finely ground three-lime phosphate, to take away two atoms of lime, you get the phosphoric acid united with one atom of lime and two atoms of water."

"And what," asked the Deacon, "becomes of the two atoms of lime?"

"They unite with the sulphuric acid," said the Doctor, "and form plaster, gypsum, or sulphate of lime."

"The molecular weight of water," continued the Doctor, "is 18; of lime, 56; of sulphuric acid, 80; of phosphoric acid, 142.

"An average sample of commercial bone-dust," continued the Doctor, "contains about 50 per cent of phosphate of lime. If we take 620 lbs. of finely-ground bone-dust, containing 310 lbs. of three-lime phosphate, and mix with it 160 lbs. of sulphuric acid (say 240 lbs. common oil of vitriol, sp. gr. 1.7), the sulphuric acid will unite with 112 lbs. of lime, and leave the 142 lbs. of phosphoric acid united with the remaining 56 lbs. of lime."

"And that will give you," said the Deacon, "780 lbs. of 'dissolved bones,' or superphosphate of lime."

"It will give you more than that," said the Doctor, "because, as I said before, the two atoms of lime (112 lbs.) are replaced by two atoms (36 lbs.) of water. And, furthermore, the two atoms of sulphate of lime produced, contained two atoms (36 lbs.) of water. The mixture, therefore, contains, even when perfectly dry, 72 lbs. of water."

"Where does this water come from?" asked the Deacon.

"When I was at Rothamsted," said I, "the superphosphate which Mr. Lawes used in his experiments was made on the farm from animal charcoal, or burnt bones, ground as fine as possible—the finer the better. We took 40 lbs. of the meal, and mixed it with 20 lbs. of water, and then poured on 30 lbs. of common sulphuric acid (sp. g. 1.7), and stirred it up rapidly and thoroughly, and then threw it out of the vessel into a heap, on the earth-floor in the barn. Then mixed another portion, and so on, until we had the desired quantity, say two or three tons. The last year I was at Rothamsted, we mixed 40 lbs. bone-meal, 30 lbs. water, and 30 lbs. acid; and we thought the additional water enabled us to mix the acid and meal together easier and better."

"Dr. Habirshaw tells me," said the Doctor, "that in making the 'Rectified Peruvian Guano' no water is necessary, and none is used. The water in the guano and in the acid is sufficient to furnish the two atoms of water for the phosphate, and the two atoms for the sulphate of lime."

"Such is undoubtedly the case," said I, "and when large quantities of superphosphate are made, and the mixing is done by machinery, it is not necessary to use water. The advantage of using water is in the greater ease of mixing."

"Bone-dust," said the Doctor, "contains about 6 per cent of water, and the sulphuric acid (sp. g. 1.7) contains about one-third its weight of water. So that, if you take 620 lbs. of bone-dust, and mix with it 240 lbs. of common sulphuric acid, you have in the mixture 117 lbs. of water, which is 45 lbs. more than is needed to furnish the water of combination."

"The superphosphate produced from 620 lbs. of bones, therefore," continued the Doctor, "would contain:

Phosphoric acid......	acid phosphate......	142 lbs.
Lime.................		56 "
Water................		36 "
Sulphuric acid........	sulphate of lime.....	160 lbs.
Lime.................		112 "
Water................		36 "
Organic matter, ash, etc., of the bones*........		335 "
Total *dry* superphosphate..................		877 "
Moisture, or loss............................		45 "
Total mixture................................		922 lbs.

* Containing nitrogen, 23½ lbs.

"There is a small quantity of carbonate of lime in the bones," said I, "which would take up a little of the acid, and you will have a remarkably good article if you calculate that the 620 lbs. of bone-dust furnish you half a ton (1,000 lbs.) of superphosphate. It will be a better article than it is practically possible to make."

"Assuming that it made half a ton," said the Doctor, "it would contain 14¼ per cent of soluble phosphoric acid, and 2⅓ per cent of nitrogen."

"With nitrogen at 20 cents per lb., and soluble phosphoric acid at 12½c. per lb., this half ton of superphosphate, made from 620 lbs. of good bone-dust, would be worth $22.50, or $45 per ton."

"Or, to look at it in another light," continued the Doctor, "a ton of bone-dust, made into such a superphosphate as we are talking about, would be worth $72.58."

"How much," asked the Deacon, "would a ton of the bone-dust be considered worth before it was converted into superphosphate?"

"A ton of bone-dust," replied the Doctor, "contains 76 lbs. of nitrogen, worth, at 18 cents per lb., $13.68, and 464 lbs. phosphoric acid, worth 7 cents per lb., $32.48. In other words, a ton of bone-dust, at the usual estimate, is worth $46.16."

"And," said the Deacon, "after it is converted into superphosphate, the same ton of bones is worth $72.58. It thus appears that you pay $26.42 per ton for simply making the phosphoric acid in a ton of bones soluble. Is'nt it paying a little too much for the whistle?"

"Possibly such is the case," said I, "and in point of fact, I think bone-dust, especially from steamed or boiled bones, can be used with more economy in its natural state than in the form of superphosphate."

Superphosphate can be made more economically from mineral phosphates than from bones—the nitrogen, if desired, being supplied from fish-scrap or from some other cheap source of nitrogen.

But for my own use I would prefer to buy a good article of superphosphate of lime, containing no nitrogen, provided it can be obtained cheap enough. I would buy the ammoniacal, or nitrogenous manure separately, and do my own mixing—unless the mixture could be bought at a less cost than the same weight of soluble phosphoric acid, and available nitrogen could be obtained separately.

A pure superphosphate—and by pure I mean a superphosphate containing no nitrogen—can be drilled in with the seed without injury, but I should be a little afraid of drilling in some of the ammoniacal or nitrogenous superphosphates with small seeds.

And then, again, the "nitrogen" in a superphosphate mixture may be in the form of nitric acid, or sulphate of ammonia, in one case, or, in another case, in the form of hair, woollen rags, hide, or leather. It is far more valuable as nitric acid or ammonia, because it will act quicker, and if I wanted hair, woollen rags, horn-shavings, etc., I would prefer to have them separate from the superphosphate.

CHAPTER XXXVIII.

SPECIAL MANURES.

Twenty-five to thirty years ago, much was said in regard to special manures. Fertilizers were prepared for the different crops with special reference to the composition of the plants.

"But it was known then, as now," said the Doctor, "that all our agricultural plants were composed of the same elements."

"True, but what was claimed was this: Some crops contain, for instance, more phosphoric acid than other crops, and for these a manure rich in phosphoric acid was provided. Others contained a large proportion of potash, and these were called 'potash crops,' and the manure prescribed for them was rich in potash. And so with the other ingredients of plants."

"I recollect it well," said the Doctor, "and, in truth, for several years I had much faith in the idea. It was advocated with consummate ability by the lamented Liebig, and in fact a patent was taken out by the Musgraves, of Liverpool, for the manufacture of Liebig's Special Manures, based on this theory. But the manures, though extensively used by the leading farmers of England, and endorsed by the highest authorities, did not in the end stand the test of actual farm practice, and their manufacture was abandoned. And I do not know of any experienced agricultural chemist who now advocates this doctrine of special manures.

"Dr. Vœlcker says: 'The ash-analyses of plants do not afford a sufficiently trustworthy guide to the practical farmer in selecting the kind of manure which is best applied to each crop.'"

"Never mind the authorities," said the Deacon; "what we want are facts."

"Well," replied the Doctor, "take the wheat and turnip crop as an illustration.

"We will suppose that there is twice the weight of wheat-straw as of grain; and that to 10 tons of bulbs there is 3 tons of turnip-tops. Now, 100 lbs. each of the ash of these two crops contain:

	Wheat crop.	*Turnip crop.*
Phosphoric acid	11.44	7.33
Potash	15.44	32.75
Sulphuric acid	2.44	11.25
Lime	5.09	19.28
Magnesia	3.33	1.56

"There are other ingredients," continued the Doctor, "but these are the most important.

"Now, if you were going to compound a manure for wheat, say 100 lbs., consisting of potash and phosphoric acid, what would be the proportions?"

The Deacon figured for a few moments, and then produced the following table:

100 LBS. SPECIAL MANURE FOR WHEAT AND TURNIPS.

	Wheat manure.	*Turnip manure.*
Phosphoric acid	42½ lbs.	18⅓ lbs.
Potash	57½ "	81⅔ "
	100 lbs.	100 lbs.

"Exactly," said the Doctor, "and yet the experiments of Lawes and Gilbert clearly prove that a soil needs to be richer in available phosphoric acid, to produce even a fair crop of turnips, than to produce a large crop of wheat. And the experience of farmers everywhere tends in the same direction. England is the greatest turnip-growing country in the world, and you will find that where one farmer applies potash to turnips, or superphosphate to wheat, a hundred farmers use superphosphate as a special manure for the turnip crop."

"And we are certainly warranted in saying," continued the Doctor, "*that the composition of a plant affords*, in practical agriculture, and on ordinary cultivated soils, *no sort of indication as to the composition of the manure it is best to apply to the crop.*"

"Again," continued the Doctor, "if the theory was a correct one, it would follow that those crops which contained the most nitrogen, would require the most nitrogen in the manure. Beans, peas, and clover would require a soil or a manure richer in available nitrogen than wheat, barley, or oats. We know that the *very reverse* is true—know it from actual, and repeated, and long-continued experiments like those of Lawes and Gilbert, and from the common experience of farmers everywhere."

"You need not get excited," said the Deacon, "the theory is a very plausible one, and while I cannot dispute your facts, I must confess I cannot see *why* it is not reasonable to suppose that a plant which contains a large amount of nitrogen should not want a manure specially rich in nitrogen; or why turnips which contain so much potash should not want a soil or manure specially rich in potash."

"Do you recollect," said I, "that crop of turnips I raised on a poor blowing-sand?"

"Yes," said the Deacon, "it was the best crop of turnips I ever saw grow."

"That crop of turnips," said I, "was due to a dressing of superphosphate of lime, with little or no potash in it."

"I know all that," said the Deacon. "I admit the fact that superphosphate is a good manure for turnips. What I want to know is the reason why superphosphate is better for turnips than for wheat?"

"Many reasons might be given," said the Doctor; "Prof. Vœlcker attributes it to the limited feeding range of the roots of turnips, as compared to wheat. 'The roots of wheat,' says Prof. Vœlcker, 'as is well known, penetrate the soil to a much greater depth than the more delicate feeding fibres of the roots of turnips. Wheat, remaining on the ground two or three months longer than turnips, can avail itself for a longer period of the resources of the soil; therefore in most cases the phosphoric acid disseminated through the soil is amply sufficient to meet the requirements of the wheat crop; whilst turnips, depending on a thinner depth of soil during their shorter period of growth, cannot assimilate sufficient phosphoric acid, to come to perfection. This is, I believe, the main reason why the direct supply of readily available phosphates is so beneficial to root-crops, and not to wheat."

"This reason," said I, "has never been entirely satisfactory to me. If the roots of the turnip have such a limited range, how are they able to get such a large amount of potash?

"It is probable that the turnip, containing such a large relative amount of potash and so little phosphoric acid, has roots capable of absorbing potash from a very weak solution, but not so in regard to phosphoric acid."

"There is another way of looking at this matter," said the Doctor. "You must recollect that, if turnips and wheat were growing in the same field, both plants get their food from the same solution. And instead of supposing that the wheat-plant has the power of taking up more phosphoric acid than the turnip-plant, we may suppose that the turnip has the power of rejecting or excluding a portion of phosphoric acid. It takes up no more potash than the wheat-plant, but it takes *less* phosphoric acid."

But it is not necessary to speculate on this matter. For the present we may accept the fact, that the proportion of potash, phosphoric acid, and nitrogen in the crop is no indication of the proper proportion in which these ingredients should be applied to the soil for these crops in manure.

It may well be that we should use special manures for special crops; but we must ascertain what these manures should be, not from analyses of the crops to be grown, but from experiment and experience.

So far as present facts throw light on this subject, we should conclude that those crops which contain the *least* nitrogen are the most likely to be benefited by its artificial application; and the crops containing the most phosphoric acid, are the crops to which, in ordinary practical agriculture, it will be unprofitable to apply superphosphate of lime.

"That," said the Doctor, "may be stating the case a little too strong."

"Perhaps so," said I, "but you must recollect I am now speaking of practical agriculture. If I wanted to raise a good crop of cabbage, I should not think of consulting a chemical analysis of the cabbage. If I set out cabbage on an acre of land, which, without manure, would produce 16 tons of cabbage, does any one mean to tell me that if I put the amount of nitrogen, phosphoric acid and potash which 10 tons of cabbage contain, on an adjoining acre, that it would produce an extra growth of 10 tons of cabbage. I can not believe it. The facts are all the other way. Plant growth is not such a simple matter as the advocates of this theory, if there be any at this late day, would have us believe."

CHAPTER XXXIX.

VALUE OF FERTILIZERS.

In 1857, Prof. S. W. Johnson, in his Report to the Connecticut Agricultural Society, adopted the following valuation:

Potash	4 cents per lb.
Phosphoric acid, insoluble in water....	4½ " " "
" " soluble " "	12½ " " "
Nitrogen	17 " " "

Analyses of many of the leading commercial fertilizers at that time showed that, when judged by this standard, the price charged was far above their actual value. In some cases, manures selling for $60 per ton, contained nitrogen, phosphoric acid, and potash worth only from $20 to $25 per ton. And one well-known manure, which sold for $28 per ton, was found to be worth only $2.33 per ton. A Bone Fertilizer selling at $50 per ton, was worth less than $14 per ton.

"In 1852," said the Doctor, "superphosphate of lime was manufactured by the New Jersey Zinc Co., and sold in New York at $50 per ton of 2,000 lbs. At the same time, superphosphate of lime made from Coprolites, was selling in England for $24 per ton of 2,240 lbs. The late Prof. Mapes commenced making "Improved Superphosphate of Lime," at Newark, N. J., in 1852, and Mr. De Burg, the same year, made a plain superphosphate of lime in Brooklyn, N. Y. The price, in proportion to value, was high, and, in fact, the same may be said of many of our superphosphate manures, until within the last few years.

Notwithstanding the comparatively high price, and the uncertain quality of these commercial manures, the demand has been steadily on the increase. We have now many honorable and intelligent men engaged in the manufacture and sale of these artificial manures, and owing to more definite knowledge on the part of the manufacturers and of the purchasers, it is not a difficult matter to find manures well worth the money asked for them.

"A correct analysis," said I, "furnishes the only sure test of value. 'Testimonials' from farmers and others are pre-eminently unreliable. With over thirty years' experience in the use of these fertilizers, I would place far more confidence on a good and reliable analysis than on any actual trial I could make in the field. Testimonials to a patent fertilizer are about as reliable as testimonials to a patent-medicine. In buying a manure, we want to know what it contains, and the condition of the constituents."

In 1877, Prof. S. W. Johnson gives the following figures, showing "the trade-values, or cost in market, per pound, of the ordinary occurring forms of nitrogen, phosphoric acid, and potash, as recently found in the New York and New England markets:

	Cents per pound.
Nitrogen in ammonia and nitrates	24
" in Peruvian Guano, fine steamed bone, dried and fine ground blood, meat, and fish	20
" in fine ground bone, horn, and wool-dust	18
" in coarse bone, horn-shavings, and fish-scrap	15
Phosphoric acid soluble in water	12½
" " "reverted," and in Peruvian Guano	9
" " insoluble, in fine bone and fish guano	7
" " " in coarse bone, bone-ash, and bone-black	5
" " " in fine ground rock phosphate	3½
Potash in high-grade sulphate	9
" in kainit, as sulphate	7½
" in muriate, or potassium chloride	6

"These 'estimated values,'" says Prof. Johnson, "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 centers 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.

"By multiplying the per cent of Nitrogen, etc., by the trade-value per pound, and then by 20, we get the value per ton of the several ingredients, and adding the latter together, we obtain the total estimated value per ton.

"The uses of the 'Valuation' are, 1st, 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. 2d, 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, etc., while the mechanical condition of a fertilizer is an item whose influence cannot always be rightly expressed or appreciated.

"The *Agricultural value* of a fertilizer is measured by the benefit received from its use, and depends upon its fertilizing effect, or crop-producing power. As a broad general rule it is true that Peruvian guano, superphosphates, fish-scraps, dried blood, potash salts, plaster, etc., have a high agricultural value which is related to their trade-value, and to a degree determines the latter value. But the rule has many exceptions, and in particular instances the trade-value cannot always be expected to fix or even to indicate the agricultural value. Fertilizing effect depends largely upon soil, crop, and weather, and as these vary from place to place, and from year to year, it cannot be foretold or estimated except by the results of past experience, and then only in a general and probable manner."

"It will be seen," said the Doctor, "that Prof. Johnson places a higher value on potash now than he did 20 years ago. He retains the same figures for soluble phosphoric acid, and makes a very just and proper discrimination between the different values of different forms of nitrogen and phosphoric acid."

"The prices," said I, "are full as high as farmers can afford to pay. But there is not much probability that we shall see them permanently reduced. The tendency is in the other direction. In a public address Mr. J. B. Lawes has recently remarked: 'A future generation of British farmers will doubtless hear with some surprise that, at the close of the manure season of 1876, there were 40,000 tons of nitrate of soda in our docks, which could not find purchasers, although the price did not exceed £12 or £13 per ton.'"

"He evidently thinks," said the Doctor, "that available nitrogen is cheaper now than it will be in years to come."

"Nitrate of soda," said I, "at the prices named, is only 2½ to 2¾ cents per lb., and the nitrogen it contains would cost less than 18 cents per lb., instead of 24 cents, as given by Prof. Johnson."

"No. 1 Peruvian Guano, 'guaranteed,' is now sold," said the

Doctor, "at a price per ton, to be determined by its composition, at the following rates:

	Value per pound.
Nitrogen (ammonia, 17½c.)	21¼c.
Soluble phosphoric acid	10 c.
Reverted " "	8 c.
Insoluble " "	2 c.
Potash, as sulphate and phosphate	7½c.

"The first cargo of Peruvian guano, sold under this guarantee, contained:

		Value per ton.
Ammonia	6.8 per cent	$23.80
Soluble phosphoric acid	3.8 " "	7.60
Reverted " "	11.5 " "	18.40
Insoluble " "	3.0 " "	1.20
Potash	3.7 " "	5.55
Estimated retail price per ton of 2,000 lbs		$56.55
Marked on bags for sale		$56.00

The second cargo, sold under this guarantee, contained:

		Value per ton.
Ammonia	11.5 per cent	$40.50
Soluble phosphoric acid	5.4 " "	10.80
Reverted " "	10.0 " "	16.00
Insoluble " "	1.7 " "	68
Potash	2.3 " "	3.45
		$71.43
Selling price marked on bags		$70.00

"It is interesting," said I, "to compare these analyses of Peruvian guano of to-day, with Peruvian guano brought to England twenty-nine or thirty years ago. I saw at Rothamsted thirty years ago a bag of guano that contained 22 per cent of ammonia. And farmers could then buy guano guaranteed by the dealers (not by the agents of the Peruvian Government), to contain 16 per cent of ammonia, and 10 per cent of phosphoric acid. Price, £9 5s. per ton of 2,240 lbs.—say $40 per ton of 2,000 lbs.

The average composition of thirty-two cargoes of guano imported into England in 1849 was as follows:

Ammonia	17.41 per cent.
Phosphoric acid	9.75 " "
Alkaline salts	8.75 " "

At the present valuation, adopted by the Agents of the Peruvian guano in New York, and estimating that 5 per cent of the phosphoric acid was soluble, and 4 per cent reverted, and that there was 2 lbs. of potash in the alkaline salts, this guano would be worth:

			Value per ton of 2,000 lbs.
Ammonia	17.41	per cent	$60.93
Soluble phosphoric acid	5.00	" "	10.00
Reverted " "	4.00	" "	6.40
Insoluble " "	75	" "	30
Potash	2.00	" "	3.00
			$80.63
Selling price per ton of 2,000 lbs			$40.00

Ichaboe guano, which was largely imported into England in 1844–5, and used extensively as a manure for turnips, contained, on the average, 7½ per cent of ammonia, and 14 per cent of phosphoric acid. Its value at the present rates we may estimate as follows:

Ammonia, 7½ per cent	$26.25
Soluble Phosphoric acid, 4 per cent	8.00
Reverted " " 10 "	16.00
	$50.25
Selling price per ton of 2,000 lbs	$21.80

The potash is not given, or this would probably add four or five dollars to its estimated value.

"All of which goes to show," said the Deacon, "that the Peruvian Government is asking, in proportion to value, from two to two and a half times as much for guano as was charged twenty-five or thirty years ago. That first cargo of guano, sold in New York under the new guarantee, in 1877, for $56 per ton, is worth no more than the Ichaboe guano sold in England in 1845, for less than $22 per ton !

"And furthermore," continued the Deacon, "from all that I can learn, the guano of the present day is not only far poorer in nitrogen than it was formerly, but the nitrogen is not as soluble, and consequently not so valuable, pound for pound. Much of the guano of the present day bears about the same relation to genuine old-fashioned guano, as leached ashes do to unleached, or as a ton of manure that has been leached in the barn-yard does to a ton that has been kept under cover."

"True, to a certain extent," said the Doctor, "but you must recollect that this 'guaranteed' guano is now sold by analysis. You pay for what you get and no more."

"Exactly," said the Deacon, "but what you get is not so good. A pound of nitrogen in the leached guano is not as available or as valuable as a pound of nitrogen in the unleached guano. An this fact ought to be understood."

"One thing," said I, "seems clear. The Peruvian Government is charging a considerably higher price for guano, in proportion to its actual value, than was charged 20 or 25 years ago. It may be, that the guano is still the cheapest manure in the market, but at any rate the price is higher than formerly—while there has been no corresponding advance in the price of produce in the markets of the world."

POTASH AS A MANURE.

On land where fish, fish-scrap, or guano, has been used freely for some years, and the crops exported from the farm, we may expect a relative deficiency of potash in the soil. In such a case, an application of unleached ashes or potash-salts will be likely to produce a decided benefit.

Clay or loamy land is usually richer in potash than soils of a more sandy or gravelly character. And on poor sandy land, the use of fish or of guano, if the crops are all sold, will be soon likely to prove of little benefit owing to a deficiency of potash in the soil. They may produce good crops for a few years, but the larger the crops produced *and sold*, the more would the soil become deficient in potash.

We have given the particulars of Lawes and Gilbert's experiments on barley. Mr. Lawes at a late meeting in London, stated that "he had grown 25 crops of barley one after the other with nitrogen, either as ammonia or nitrate of soda, but without potash, and that by the use of potash they had produced practically no better result. This year (1877), for the first time, the potash had failed a little, and they had now produced 10 or 12 bushels more per acre with potash than without, showing that they were coming to the end of the available potash in the soil. This year (1877), they obtained 54 bushels of barley with potash, and 42 bushels without it. Of course, this was to be expected, and they had expected it much sooner. The same with wheat; he expected the end would come in a few years, but they had now gone on between 30 and 40 years. When the end came they would not be sorry, because then they would have the knowledge they were seeking for."

Dr. Vœlcker, at the same meeting remarked: "Many soils contained from 1½ to 2 per cent of available potash, and a still larger quantity locked up, in the shape of minerals, which only gradually came into play; but the quantity of potash carried off in crops did not exceed 2 cwt. per acre, if so much. Now 0.1 per cent of any constituent, calculated on a depth of six inches, was equivalent to one ton per acre. Therefore, if a soil contained only 0.1 per cent of potash, a ton of potash might be carried off from a depth of 6 inches. But you had not only 0.1 per cent, but something like 1½ per cent and upwards in many soils. It is quite true there were many soils from which you could not continuously take crops without restoring the potash."

"In all of which," said the Doctor, "there is nothing new. It does not help us to determine whether potash is or is not deficient in our soil."

"That," said I, "can be ascertained only by actual experiment. Put a little hen-manure on a row of corn, and on another row a little hen-manure and ashes, and on another row, ashes alone, and leave one row without anything. On my farm I am satisfied that we need not buy potash-salts for manure. I do not say they would do no good, for they may do good on land not deficient in available potash, just as lime will do good on land containing large quantities of lime. But potash is not what my land needs to make it produce maximum crops. It needs available nitrogen, and possibly soluble phosphoric acid."

The system of farming adopted in this section, is much more likely to impoverish the soil of nitrogen and phosphoric acid than of potash.

If a soil is deficient in potash, the crop which will first indicate the deficiency, will probably be clover, or beans. Farmers who can grow large crops of red-clover, need not buy potash for manure.

On farms where grain is largely raised and sold, and where the straw, and corn-stalks, and hay, and the hay from clover-seed are retained on the farm, and this strawy manure returned to the land, the soil will become poor from the lack of nitrogen and phosphoric acid long before there would be any need of an artificial supply of potash.

On the other hand, if farmers should use fish, or guano, or superphosphate, or nitrate of soda, and sell all the hay, and straw, and potatoes, and root-crops, they could raise, many of our sandy soils would soon become poor in available potash. But even in this case the clover and beans would show the deficiency sooner than wheat or even potatoes.

"And yet we are told," said the Deacon, "that potatoes contain no end of potash."

"And the same is true," said I, "of root-crops, such as mangel-wurzel, turnips, etc., but the fact has no other significance than this: If you grow potatoes for many years on the same land and manure them with nitrogenous manures, the soil is likely to be speedily impoverished of potash."

"But suppose," said the Deacon, "that you grow potatoes on the same land without manure of any kind, would not the soil become equally poor in potash?"

"No," said I, "because you would, in such a case, get very small crops—small, not from lack of potash, but from lack of nitrogen. If I had land which had grown corn, potatoes, wheat, oats, and hay, for many years without manure, or an occasional dressing of our common barnyard-manure, and wanted it to produce a good crop of potatoes, I should not expect to get it by simply applying potash. The soil might be poor in potash, but it is almost certain to be still poorer in nitrogen and phosphoric acid.

Land that has been manured with farm-yard or stable-manure for years, no matter how it has been cropped, is not likely to need potash. The manure is richer in potash than in nitrogen and phosphoric acid. And the same may be said of the soil.

If a farmer uses nitrogenous and phosphatic manures on his clayey or loamy land that is usually relatively rich in potash, and will apply his common manure to the sandy parts of the farm, he will rarely need to purchase manures containing potash.

CHAPTER XL.

RESTORING FERTILITY TO THE SOIL.

BY SIR J. B. LAWES, BART., LL.D., F.R.S., ROTHAMSTED, ENG.

A relation of mine, who already possessed a very considerable estate, consisting of light land, about twenty years ago purchased a large property adjoining it at a very high price. These were days when farmers were flourishing, and they no more anticipated what was in store for them in the future, than the inhabitants of the earth in the days of Noah.

Times have changed since then, and bad seasons, low prices of wheat, and cattle-disease, have swept off the tenants from these two estates, so that my relation finds himself now in the position of being the unhappy owner and occupier of five or six farms, extending over several thousand acres—one farm alone occupying an area of two thousand four hundred acres. Fortunately for the owner, he possesses town property in addition to his landed estates, so that the question with him is not, as it is with many land owners, how to find the necessary capital to cultivate the land, but, having found the capital, how to expend it in farming, so as to produce a proper return.

It is not very surprising that, under these circumstances, my opinion should have been asked. What, indeed, would have been the use of a relation, who not only spent all his time in agricultural experiments, but also pretended to teach our neighbors how to farm on the other side of the Atlantic, if he could not bring his science to bear on the land of an adjoining county! Here is the land—my relation might naturally say—here is the money, and I have so much confidence in your capacity that I will give you *carte-blanche* to spend as much as you please—what am I to do?

An inspection of the property brought out the following facts—that all the land was very light, and that you might walk over the fresh plowed surface in the wettest weather without any clay sticking to your boots: still a portion of the soil was dark in color, and therefore probably contained a sufficient amount of fertility to make cultivation profitable, provided the management could be conducted with that care and economy which are absolute essentials in a business where the expenditure is always pressing closely upon the income.

Upon land of this description meat-making is the backbone of the system, which must be adopted, and a large breeding flock of sheep the first essential towards success.

Science can make very little improvement upon the four-course rotation—roots, barley, clover, and wheat, unless, perhaps, it may be by keeping the land in clover, or mixed grass and clover, for two or three years.

A good deal of the land I was inspecting was so light, that, in fact, it was hardly more than sand, and for some years it had been left to grow anything that came up, undisturbed by the plow.

To a practised eye, the character of the natural vegetation is a sure indication of the fertility of the soil. Where herds of buffaloes are to be seen—their sides shaking with fat—it is quite evident that the pastures upon which they feed cannot be very bad; and in the same way, where a rank growth of weeds is found springing up upon land that has been abandoned, it may be taken for certain that the elements of food exist in the soil. This ground was covered with vegetation, but of the most impoverished description, even the "Quack" or "Couch-grass" could not form a regular carpet, but grew in small, detached bunches; everything, in fact, bore evidence of poverty.

Possibly, the first idea which might occur to any one, on seeing land in this state, might be: Why not grow the crops by the aid of artificial manures?

Let us look at the question from two points of view: first, in regard to the cost of the ingredients; and, secondly, in regard to the growth of the crop.

We will begin with wheat. A crop of wheat, machine-reaped, contains, as carted to the stack, about six pounds of soil ingredients in every one hundred pounds; that is to say, each five pounds of mineral matter, and rather less than one pound of nitrogen, which the plant takes from the soil, will enable it to obtain ninety-four pounds of other substances from the atmosphere. To grow a crop of twenty bushels of grain and two thousand pounds of straw, would require one hundred and sixty pounds of minerals, and about thirty-two pounds of nitrogen; of the one hundred and sixty pounds of minerals, one-half would be silica, of which the soil possesses already more than enough; the remainder, consisting of about eighty pounds of potash and phosphate, could be furnished for from three to four dollars, and the thirty-two pounds of nitrogen could be purchased in nitrate of soda for six or eight dollars.

The actual cost of the ingredients, therefore, in the crop of twenty bushels of wheat, would be about ten to twelve dollars. But as this manure would furnish the ingredients for the growth of both straw and grain, and it is customary to return the straw to the land, after the first crop, fully one-third of the cost of the manure might, in consequence, be deducted, which would make the ingredients of the twenty bushels amount to six dollars. Twenty bushels of wheat in England would sell for twenty-eight dollars; therefore, there would be twenty-two dollars left for the cost of cultivation and profit.

A French writer on scientific agriculture has employed figures very similar to the above, to show how French farmers may grow wheat at less than one dollar per bushel. At this price they might certainly defy the competition of the United States. It is one thing, however, to grow crops in a lecture room, and quite another to grow them in a field. In dealing with artificial manures, furnishing phosphoric acid, potash, and nitrogen, we have substances which act upon the soil in very differents ways. Phosphate of lime is a very insoluble substance, and requires an enormous amount of water to dissolve it. Salts of potash, on the other hand, are very soluble in water, but form very insoluble compounds with the soil. Salts of ammonia and nitrate of soda are perfectly soluble in water. When applied to the land, the ammonia of the former substance forms an insoluble compound with the soil, but in a very short time is converted into nitrate of lime; and with this salt and nitrate of soda, remains in solution in the soil water until they are either taken up by the plant or are washed away into the drains or rivers.

Crops evaporate a very large amount of water, and with this water they attract the soluble nitrate from all parts of the soil. Very favorable seasons are therefore those in which the soil is neither too dry nor too wet; as in one case the solution of nitrate becomes dried up in the soil, in the other it is either washed away, or the soil remains so wet that the plant cannot evaporate the water sufficiently to draw up the nitrates which it contains.

The amount of potash and phosphoric acid dissolved in the water is far too small to supply the requirements of the plant, and it is probable that what is required for this purpose is dissolved by some direct action of the roots of the plant on coming in contact with the insoluble phosphoric acid and potash in the soil.

In support of this view, I may mention that we have clear evidence in some of our experiments of the wheat crop taking up both phosphates and potash that were applied to the land thirty years ago.

To suppose, therefore, that, if the ingredients which exist in twenty bushels of wheat and its straw, are simply applied to a barren soil, the crop will be able to come in contact with, and take up these substances, is to assume what certainly will not take place.

I have often expressed an opinion that arable land, could not be cultivated profitably by means of artificial manures, unless the soil was capable of producing, from its own resources, a considerable amount of produce; still the question had never up to this time come before me in a distinct form as one upon which I had to decide one way or the other. I had, however, no hesitation in coming to the conclusion, that grain crops could never be grown at a profit upon my relation's land, and that consequently, for some years, it would be better to give up the attempt, and try to improve the pasture.

After what I have said about the insolubility of potash and phosphoric acid, it may possibly be asked—why not give a good dose of these substances at once, as they do not wash out of the soil—say enough to grow sixty crops of grain, and apply the nitrate, or ammonia every year in just sufficient amounts to supply the wants of the crop?

The objections to this plan are as follows: assuming the most favorable conditions of climate, and the largest possible produce, the wheat could certainly not take up the whole of the thirty-two pounds of nitrogen applied, and the crop which requires nearly one pound of nitrogen in every one hundred pounds of gross produce, would be certainly less than three thousand two hundred pounds, if supplied with only thirty-two pounds of nitrogen. If we take the total produce of the best and worst wheat crop, grown during the forty years of our experiments, we shall arrive at a better understanding in the matter. The following are the figures :

WEIGHT OF DRY PRODUCE OF WHEAT PER ACRE.

	Straw and Grain.
1863	9330 lbs.
1879	3859 "

In order to ascertain the increase due to the nitrogen of the salts of ammonia or nitrate of soda, we must deduct from the crop the produce obtained, where mineral manures without nitrogen were used. In 1863 this amount was three thousand pounds, and in 1879 it was one thousand two hundred pounds. Deducting these amounts from the gross produce in each case, leaves six thousand three hundred and thirty as the produce due to the nitrogen in the season of 1863, and two thousand six hundred and fifty-nine as the produce due to the nitrogen in 1879.

But in each case we applied the same amount of nitrogen, eighty-seven pounds; and as the amount of nitrogen in a wheat crop, as carted from the field, contains less than one per cent. of nitrogen, it is evident that if all that was contained in the manure had been taken up by the plant, the increased crop should have weighed eight thousand seven hundred pounds instead of six thousand three hundred and thirty. Thus even in our best year, some of the nitrogen applied failed to produce growth; and when we come to the bad year we find that only twenty-six and a half pounds were taken up out of the eighty-seven pounds applied, thus leaving more than two-thirds of the whole unaccounted for.

Seasons are only occasionally either very bad or very good. What we call an average season does not differ very much from the mean of the best and worst years, which in this case would be represented by a crop of four thousand four hundred and ninety-four pounds, containing nearly forty-five pounds of nitrogen. I may say that, although I have employed one per cent. to avoid fractions in my calculations, strictly speaking three-quarters of a per cent. would more nearly represent the real quantity. If, however, on the average, we only obtain about forty-five pounds from an application of about eighty-seven pounds of nitrogen, it is evident that not more than one-half of the amount applied enters into the crop.

Now in dealing with a substance of so costly a nature as ammonia, or nitrate of soda—the nitrogen contained in which substances cannot cost much less than twenty-five cents per pound by the time it is spread upon the land, it becomes a question of importance to know what becomes of the other half, or the residue whatever it may be, which has not been taken up by the crop. Part is undoubtedly taken up by the weeds which grow with the wheat, and after the wheat has been cut. Part sinks into the sub-soil and is washed completely away during the winter.

I, myself, am disposed to think that the very great difference in the size of the Indian corn crops, as compared with the wheat crops in the States, is partly accounted for by their greater freedom from weeds, which are large consumers of nitric acid, and, in the case of the wheat crop, frequently reduce the yield by several bushels per acre. It must, however, be borne in mind that, though the wheat is robbed of its food where there are weeds, still if there were no weeds, the amount of nitric acid which the crop could not get hold of, would, in all probabilty, be washed out of the soil during the ensuing winter. I come to the conclusion, therefore, that the nitrogen alone, which would be required to produce one bushel of wheat, would cost not much less than fifty cents ; and that, in consequence, wheat-growing by means of artificial manures, will not pay upon very poor land.

I have said that the land, about which I was consulted, had not been plowed for several years, and that although nature had done all she could to clothe the soil with vegetation, the most disheartening feature in the case was, the poverty of the weeds. A thistle may be a giant or a dwarf, according to circumstances ; here they were all dwarfs. The plaintain, which I believe is sometimes sown in these districts for food, has a very deep root ; here the plants were abundant, but the leaves were very small and lay so close to the ground, that, as the manager informed me, "the sheep were often injured from the amount of sand which they swallowed with the leaves when feeding."

At Rothamsted, the analyses of the rain water passing through the ordinary soil of one of my fields, which has been kept free from vegetation, have shown that the amount of nitric acid liberated in a soil, and washed out each year, is very large. Taking the ten years during which these special experiments have been in progress, I should think that the loss of nitrogen would be equal to, or possibly exceed, the amount of that substance removed by the average crops grown in the United States.

The results obtained by the rain gauges, are further completely confirmed by those in an adjoining field, where wheat and fallow have been grown alternately for twenty-seven years. The liberation of nitric acid, during the year of rest, produced for a time a large growth of wheat, but it was done at a very great waste of the fertility of the soil, and the produce is now, in proportion, considerably lower than that grown on the continuously unmanured land.

These results, if they are to be accepted as correct, must bring about a very considerable change in the generally received views in regard to fertility. We not only see more clearly the connection between a former vegetation and the stored up fertility in our soil, but we also see the importance of vegetation at the present day, as the only means by which the loss of nitric acid is prevented. The more completely the land is covered with vegetation, and the more growth there is, the greater will be the evaporation of water, and the less will be the loss of nitric acid by drainage.

I was not at all surprised to find, that the surface soil of a wood on my farm, was poorer in nitrogen than the soil of an old permanent pasture, to which no manure had been applied for twenty-five years, though during the whole period, the crop of hay had been removed every year from the land. The wood to which I refer is covered with oak, centuries old, and the foliage is so dense that but little underwood or other vegetation can grow beneath it. If both the wood and the pasture were put into arable cultivation, I have no doubt that the pasture would prove much more fertile than the wood land.

In our experiments on permanent pasture, it has been observed that the character of the herbage is mainly dependent on the food supplied. Weeds, and inferior grasses, can hold their own as long as poverty exists, but with a liberal supply of manure, the superior grasses overgrow and drive out the bad grasses and weeds. In consequence of the low price of wheat a good deal of land in England has been laid down to permanent pasture, and much money has been spent in cleaning the land preparatory to sowing the grass-seeds. I have on more occasions than one, suggested that the money employed in this process would be better expended in manure, by which the weeds would be "improved" off the face of the land. While walking over the abandoned portion of these estates I explained my views upon this point to the manager. They were, however, received with the usual skepticism, and the rejoinder that "there was only one way of getting rid of the weeds, which was by the plow and fire."

There is nothing that speaks to me so forcibly as color in vegetation; when travelling by rail, I do not require to be told that such a farm is, or is not, in high condition, or that we are passing through a fertile or infertile district. There is a peculiar green color in vegetation which is an unmistakable sign that it is living upon the fat of the land. I need hardly say that, in this case, the color of the vegetation gave unmistakable signs of the poverty of the soil; but in the midst of the dingy yellowish-green of the herbage, I came upon one square of bright green grass. In answer to my enquiry I was told that, a "lambing-fold had been there last year," and my informant added his opinion, "that the manure would be so strong that it would kill anything!" It had certainly killed the weeds, but in their place, some good grasses had taken possession of the soil.

The plan I proposed to adopt was, to spend no more money on tillage operations, but to endeavor to improve the pasture by giving to it the food necessary to grow good grasses, sowing at the same time a small quantity of the best seeds. I further suggested that a flock of sheep should be allowed to run over the whole of the land by day, and be folded there every night—about one pound of cotton-seed cake per head being allowed daily. By this means, as the fold would be moved every day, the amount of manure deposited on the soil could be estimated.

If there were a hundred sheep, receiving one pound of decorticated cotton-seed cake per head, daily, and the hurdles were arranged to enclose a space of twenty-five by twenty yards, in the course of ten days an acre of land would have received manure from one thousand pounds of cake; which amount would supply seventy-seven pounds of nitrogen, sixty-eight pounds of phosphate of lime, and thirty-two pounds of potash. This amount of cake would cost about sixteen dollars.

As regards the value of the cake as a food, it is somewhat difficult to form an estimate; but it takes nine or ten pounds of dry food—say roots, cake, and hay—to produce an increase of one pound of live weight in sheep. The cake has certainly a higher feeding value, than either hay or roots, but I will here give it only the same value, and consider that one hundred and ten pounds of increase of the animal was obtained by the consumption of the one thousand pounds of cake. The value of the increase of the live weight would be in England fully eleven dollars, leaving five dollars as the cost of the manure. Now the cake furnished seventy-seven pounds of nitrogen alone, which, if purchased in an artificial manure, would have cost nineteen dollars; and the other substances supplied by the cake, would have cost from four to five dollars more. The manures required, therefore, would be obtained much more cheaply by this than by any other process.

Labor would be saved by not cultivating the land. Manure would be saved by substituting vegetation which grows under or above ground, almost all the year round. And, by feeding the stock with cake, the necessary fertility would be obtained at the lowest possible cost.

It is probable that the land would require this treatment to be repeated for several years, before there would be a fair growth of gr ss. The land might then be broken up and one grain crop be taken, then it might again be laid down to grass.

Hitherto, I have considered a case where fertility is almost absent from the land, this, however, is an exception, as agriculture generally is carried on upon soils which contain large stores of fertility, though they may be very unequally distributed. By analysis of the soil we can measure the total amount of fertility which it contains, but we are left in ignorance in regard to the amount of the ingredients which are in such a form that the crops we cultivate can make use of them.

At Rothamsted, among my experiments on the growth of continuous wheat, at the end of forty years, the soil supplied with salts of ammonia has yielded, during the whole time, and still continues to yield, a larger produce than is obtained by a liberal supply of phosphates and alkaline salts without ammonia.

When we consider that every one hundred pounds of wheat crop, as carted to the stack, contains about five per cent. of mineral matter, and one per cent. of nitrogen, it is impossible to avoid the conclusion that my soil has a large available balance of mineral substances which the crop could not make use of for want of nitrogen. The crop which has received these mineral manures now amounts to from twelve to thirteen bushels per acre, and removes from the land about sixteen pounds of nitrogen every year.

Analyses of the soil show that, even after the removal of more than thirty crops in succession, without any application of manure containing ammonia, the soil still contains some thousands of pounds of nitrogen. This nitrogen is in combination with carbon ; it is very insoluble in water, and until it becomes separated from the carbon, and enters into combination with oxygen, does not appear to be of any use to the crop.

The combination of nitrogen with oxygen, is known as nitric acid. The nitric acid enters into combination with the lime of the soil, and in this form becomes the food of plants.

From its great importance in regard to the growth of plants, nitric acid might be called the main spring of agriculture, but being perfectly soluble in water, it is constantly liable to be washed out of the soil. In the experiment to which I have referred above—where wheat is grown by mineral manures alone—we estimate that, of the amount of nitric acid liberated each year, not much more than one-half is taken up by the crop.

The wheat is ripe in July, at which time the land is tolerably free from weeds; several months, therefore, occur during which there is no vegetation to take up the nitric acid; and even when the wheat is sown at the end of October, much nitric acid is liable to be washed away, as the power of the plant to take up food from the soil is very limited until the spring.

The formation of nitric acid, from the organic nitrogen in the soil, is due to the action of a minute plant, and goes on quite independent of the growth of our crops. We get, however, in the fact an explanation of the extremely different results obtained by the use of different manures. One farmer applies lime, or even ground limestone to a soil, and obtains an increase in his crops; probably he has supplied the very substance which has enabled the nitrification of the organic nitrogen to increase; another applies potash, a third phosphates; if either of these are absent, the crops cannot make use of the nitric acid, however great may be the amount diffused through the soil.

It may possibly be said that the use of mineral manures tends to exhaust the soil of its nitrogen; this may, or may not, be true; but even if the minerals enable the crop to take up a larger amount of the nitric acid found in the soil year by year, this does not increase the exhaustion, as the minerals only tend to arrest that which otherwise might be washed away.

We must look upon the organic nitrogen in the soil, as the main source of the nitrogen which grows our crops. Whatever may be the amount derived from the atmosphere, whether in rain, or dew; or from condensation by the soil, or plants, it is probable that, where the land is in arable cultivation, the nitrogen so obtained, is less than the amount washed out of the soil in nitric acid. Upon land which is never stirred by the plow, there is much less waste and much less activity.

The large increase in the area of land laid down to permanent pasture in England, is not due alone to the fall in the price of grain. The reduction of fertility in many of the soils, which have been long under the plow, is beginning to be apparent. Under these circumstances a less exhausting course of treatment becomes necessary, and pasture, with the production of meat, milk, and butter, takes the place of grain fields.

APPENDIX.

LETTER FROM EDWARD JESSOP, YORK, PA.

YORK, PA., March 16, 1876.

Joseph Harris, Esq., Moreton Farm, Rochester, N. Y.:

DEAR SIR—Your favor of the 22d of last month came safely to hand, and I am truly obliged to you for the reply to my question.—You ask, can I help you with facts or suggestions, on the subject of manure? I fear not much; but it may be useful to you to know what others need to know. I will look forward to the advent of "Talks on Manures" with much interest, hoping to get new light on a subject second to none in importance to the farmer.

I have done a little at composting for some years, and am now having a pile of about forty cords, made up of stable-manure and earth taken from the wash of higher lands, turned and fined. The labor of digging and hauling the earth, composting in thin layers with manure, turning, and fining, is so great, I doubt whether it pays for most farm crops—this to be used for mangel-wurzel and market-garden.

The usual plan in this county is to keep the stable-manure made during winter, and the accumulation of the summer in the barn-yard, where it is soaked by rain, and trampled fine by cattle, and in August and September is hauled upon ground to be seeded with wheat and grass-seeds. I do not think there is much piling and turning done.

My own conclusions, not based on accurate experiments, however, are, that the best manure I have ever applied was prepared in a covered pit on which cattle were allowed to run, and so kept well tramped—some drainage into a well, secured by pouring water upon it, when necessary, and the drainage pumped and distributed over the surface, at short intervals, particularly the parts not well tramped, and allowed to remain until it became a homogeneous mass, which it will do without having undergone so active a fermentation as to have thrown off a considerable amount of gas.

The next best, composting it with earth, as above described, piled about five or six feet high, turned as often as convenient, and kept moist enough to secure fermentation.

Or, to throw all the manure as made into a covered pit, until it is thoroughly mixed and made fine, by allowing hogs to run upon it and root at will; and when prepared for even spreading, apply it as a top-dressing on grass-land—at any convenient time.

As to how many loads of fresh manure it takes to make one of well-rotted manure, it may be answered approximately, *three to one*, but that would depend a good deal on the manner of doing it, and the amount of rough material in it. If well trodden by cattle under cover, and sufficient drainage poured over it, to prevent any violent fermentation, the loss of weight, I think, would not be very great, nor the bulk lessened over one-half.

Many years ago an old and successful farmer said to me, "if you want to get the full benefit of manure, spread it as a top-dressing on some *growing crop*," and all my experience and observation since tend to confirm the correctness of his advice.

While on this subject, allow me to protest against the practice of naming the quantity of manure applied to a given space, as so many *loads*, as altogether too indefinite. The bushel or cord is a definite quantity, which all can understand.

The average price of good livery stable horse-manure at this place has been for several years four dollars a cord.

With two and a half miles to haul, I am trying whether keeping a flock of 50 breeding ewes, and feeding liberally with wheat bran, in addition to hay and pasture, will not produce the needed manure more cheaply.

Respectfully yours, EDWARD JESSOP.

P. S.—You ask for the average weight of a cord of manure, such as we pay four dollars for.

I had a cord of horse-stable manure from a livery stable in York which had been all the time under cover, with several pigs running upon it, and was moist, without any excess of wet, loaded into a wagon-box holding an entire cord, or 128 cubic feet, tramped by the wagoner three times while loading.

The wagon was weighed at our hay-scales before loading, and then the wagon and load together, with a net result for the manure of 4,400 lbs. I considered this manure rather better than the average. I had another load, from a different place, which weighed over 5,000 lbs., but on examination it was found to contain a good deal of coal ashes. We never *buy* by the ton. Harrison Bros. & Co., Manufacturing Chemists, Philadelphia, rate barnyard-manure as worth $5.77 per ton, and say that would be about $7.21 per cord, which would be less than 1¼ tons to the cord. If thrown in loosely, and it happened to be *very dry*, that might be possible.

Waring, in his "Handy Book of Husbandry," page 201, says, he caused a cord of well-trodden livery stable manure containing the usual proportion of straw, to be carefully weighed, and that the cord weighed 7,080 lbs.

The load I had weighed, weighing 4,400 lbs., was considered by the wagoner and by myself as a fair sample of good manure. In view of these wide differences, further trials would be desirable. Dana, in his "Muck Manual," says a cord of green cow-dung, pure, as dropped, weighs 9,289 lbs.

Farmers here seldom draw manure with less than three, more generally with four horses or mules; loading is done by the purchaser. From the barn-yard, put on loose boards, from 40 to 60 bushels are about an average load.

In hauling from town to a distance of three to five miles, farmers generally make two loads of a cord each, a day's work. From the barn-yard, a very variable number, per day. In my own case, two men with three horses have been hauling six and seven loads of sixty bushels, fine compost, a distance of from one-half to three-fourths of a mile, up a long and rather steep hill, and spreading from the wagon, as hauled, upon grass-sod.

Our larger farmers often have one driver and his team, two wagons, one loading, while the other is drawn to the field; the driver slips off one of the side-boards, and with his dung-hook draws off piles at nearly equal distances, to be spread as convenient. EDWARD JESSOP.

LETTER FROM DR. E. L. STURTEVANT, SOUTH FRAMINGHAM, MASS.

SOUTH FRAMINGHAM, MASS., April 2, 1876.

FRIEND HARRIS—Manure about Boston is sold in various ways. First, according to the number of animals kept; price varying so much, that I do not venture to name the figures. By the cord, to be trodden over while loading; never by weight, so far as I can learn—price from 0 to $12.00 per cord, according to season, and various accidental circumstances. During the past winter, manure has been given away in Boston. Handling, hauling to the railroad, and freight costing $4 per cord for carrying 30 miles out. Market-gardeners usually haul manure as a return freight on their journeys to and from market. About South Framingham, price stiff at $8 a cord in the cellar, and this may be considered the ruling suburban price. Very friendly yours,

E. LEWIS STURTEVANT.

LETTER FROM M. C. WELD.

NEW YORK, Nov. 9, 1876.

MY DEAR HARRIS—I don't know what I can write about manures, that would be of use. I have strong faith in humus, in ashes, leached and unleached, in lime, gas-lime, plaster, bones, ammonia ready formed, nitrates ready formed, not much in meat and blood, unless they are *cheap*. Nevertheless, they often are cheap, and produce splendid effects. I believe in sulphuric acid, with organic nitrogenous manures; the composting of meat, blood, hair, etc., with peat and muck, and wetting it down with dilute sulphuric acid. I believe in green-manuring, heartily, and in tillage, tillage, tillage. Little faith in superphosphates and compounded manures, at selling prices. Habirshaw's guano is good enough. So much for my creed. Truly yours, M. C. WELD.

LETTER FROM PETER HENDERSON.

NEW YORK, Oct. 26, 1876.

Mr. Joseph Harris:

DEAR SIR—If you will refer to my work "Gardening for Profit," New Edition, page 34, you will get about all the information I possess on Manures, except that I do not say anything about price. In a general way it might be safe to advise that whenever *a ton* (it is always best to speak of manures by weight) of either cow, horse, hog, or other stable-manure can be laid on the ground for $3, it is cheaper than commercial fertilizers of any kind at their usual market rates. This $3 per ton, I think, would be about the average cost in New York, Boston, or Philadelphia. We never haul it on the ground until we are ready to plow it in. If it has to be taken from the hog or cattle yards, we draw it out into large heaps, convenient to where it is to be put on the land, turning it, to keep it from burning or "fire-fanging," if necessary. None of our farmers or market-gardeners here keep it under cover. The expense of such covering and the greater difficulties in getting at it, for the immense quantities we use, would be greater than the benefits to be derived from keeping it under cover—benefits, in fact, which, I think, may be greatly overrated. Very truly yours, PETER HENDERSON.

LETTER FROM J. M. B. ANDERSON, ED. "CANADA FARMER," TORONTO.

"CANADA FARMER" OFFICE, TORONTO, March 29, 1876.

J. Harris, Esq.:

DEAR SIR—Yours of the 25th inst. is to hand, and I shall be most happy to render you any assistance in my power. The work you undertake is in able hands, and I have every confidence that, when completed, it will form an invaluable acquisition to the agricultural literature of the day.

Manure in this city is usually sold by the two-horse load—about 1½ tons—at the rate of $1 per load, or 66 cents per ton. The load contains just about a cord of manure, consequently a cord will weigh about 1½ tons.

With reference to the general management of manure in Canada, I may say that the system followed differs in no material respect from that of New York and the other Eastern States. It is usually kept over winter in the open barn-yard (rarely under cover, I am sorry to say), laid out on the land about the time of disappearance of last snow, and plowed in. In some cases it is not carted out until the land is ready for immediate plowing. With some of our more advanced farmers, the system has lately been adopted of keeping manure under cover and sprinkling it thoroughly at intervals with plaster and other substances. Tanks are also becoming more common than formerly, for the preservation of liquid manure, which is usually applied by means of large, perforated hogsheads, after the manner of street-watering.

You ask, how the manure is managed at Bow Park, Brantford. That made during fall and winter is carefully kept in as small bulk as possible, to prevent exposure to the weather. In February and March it is drawn out and put in heaps 8 feet square, and well packed, to prevent the escape of ammonia. In spring, as soon as practicable, it is spread, and plowed under immediately. Manure made in spring and summer is spread on the field at once, and plowed under with a good, deep furrow

Very truly yours, J. M. B. ANDERSON, Ed. *Canada Farmer.*

MANURE STATISTICS OF LONG ISLAND.

THE MANURE TRADE OF LONG ISLAND—LETTER FROM J. H. RUSHMORE.

OLD WESTBURY, Long Island, April 6, 1876.

Joseph Harris, Esq.:

DEAR SIR—The great number of dealers in manure in New York precludes accuracy, yet Mr. Skidmore (who has been testifying voluminously before the New York Board of Health in relation to manure and street dirt), assures me that the accompanying figures are nearly correct. I enclose statement, from two roads, taken from their books, and the amount shipped over the other road I obtained verbally from the General Freight Agent, and embody it in the sheet of statistics.

The Ash report I *know* is correct, as I had access to the books showing the business, for over ten years. I have made numerous applications, verbally, and by letter, to our largest market gardeners, but there seems to exist a general and strong disinclination to communicate anything worth knowing. I enclose the best of the replies received. Speaking for some of our largest gardeners, I may say that they cultivate over one hundred acres, and use land sufficiently near to the city to enable them to dispense with railroad transportation in bringing manure to their places and marketing crops. I have noticed that one of the shrewdest gardeners invariably composts horn-shavings and bone-meal with horse-manure several months before expecting to use it. A safe average of manure used per acre by gardeners, may be stated at ninety (90) tubs, and from two hundred to twenty hundred pounds of fertilizer in addition, according to its strength, and the kind of crop.

The following railroad manure statistics will give a generally correct idea of the age of manure, when used:

STATEMENT OF MANURE SENT FROM JAN. 1 TO DEC. 31, 1875.

	Over F. N. S. & C. R. R.	*Over Southern R. R.*
January	1,531 tubs.	5,815 tubs.
February		4,357 "
March	740 "	12,217 "
April	12,122 "	7,055 "
May	7,383 "	3,049 "
June	5,725 "	1,365 "
July	6,473½ "	685 "
August	6,370½ "	2,911 "
September	3,197 "	14,702 "
October	880 "	660 "
November	512 "	840 "
December	1,406 "	4,023 "
	46,340 tubs.	57,679 tubs.

A tub is equal to 14 bushels.

Hobson, Hurtado & Co. report the amount of Peruvian guano sold in this country last year at thirty thousand tons.

Estimated number of horses in New York city, 100,000.

Estimated product of manure per horse. Four cords.

Estimated proportion of straw to pure excrement. One-half.

Amount shipped direct from stables. Nearly all.

Amount shipped on vessels. One-half.

Length of time the unshipped manure remains in heaps. From three to four months.

Average cost per horse, annually. $3.

Greatest distance of shipment. Virginia.

Average amount shipped via L. I. R. R. 60,000 tubs.

Price of manure per tub delivered on cars or vessel. 80 cents.

Average amount put on car. 40 tubs.

STATISTICS OF ASH TRADE.—Time when ashes are delivered. From middle of June to middle of October.

Places from which they are mostly shipped. Montreal, Belleville, and Toronto (Canada).

Method of transportation. Canal boats.

Average load per boat. About 8,000 bushels.

Average amount annually sold. 360,000 bushels.

Average cost delivered to farmers. 20½ cents per bushel.

	Per Acre, about.
Amount used by farmers for potatoes.........	60 tubs.
" " " " " cabbage (late)....	50 "
" " " " " corn.............	12 "

Amount of guano used on Long Island, as represented by the books of Chapman & Vanwyck, and their estimate of sales by other firms, 5,000 tons.

The fertilizers used on the Island are bought almost exclusively by market gardeners or farmers, who do a little market gardening, as it is the general conviction that ordinary farm-crops will not give a compensating return for their application. Most market gardeners keep so little stock that the manure made on the place is very inconsiderable. Our dairy farmers either compost home-made manures with that from the city, spread it on the land for corn in the spring, or rot it separate, to use in the fall for wheat, on land that has been cropped with oats the same year. The manure put on for potatoes is generally estimated to enrich the land sufficient for it to produce one crop of winter grain, and from five to seven crops of grass, when it is again plowed and cultivated in rotation with, first, corn, second, potatoes or oats, and is reseeded in autumn of the same year.

Fish and fish guano are largely used on land bordering the water, and adjacent to the oil-works. The average price for guano in bulk at oil-works is $12 per ton. The average price for fish on wharf is $1.50 per thousand, and it is estimated that, as a general average, 6,000 fish make a ton of guano. The fish, when applied to corn, are placed two at each hill, and plowed under at any time after the corn is large enough to cultivate. Seaweed is highly prized by all who use it, and it will produce a good crop of corn when spread thickly on the land previous to plowing.

Very respectfully, J. H. RUSHMORE.

LETTER FROM JOHN E. BACKUS.

NEWTOWN, Long Island, N. Y., March 2nd, 1876.

Mr. G. H. Rushmore:

DEAR SIR.—Some farmers and market-gardeners use more, and some less, manure, according to crops to be raised. I use about 30 good two-horse wagon-loads to the acre, to be applied in rows or broad-casted, as best for certain crops. I prefer old horse-dung for most all purposes.

Guano, as a fertilizer, phosphate of bone and blood are very good; they act as a stimulant on plants and vegetation, and are highly beneficial to some vegetation—more valuable on poor soil than elsewhere, except to produce a thrifty growth in plants, and to insure a large crop.

By giving you these few items they vary considerably on different parts of the Island; judgment must be used in all cases and all business. Hoping these few lines may be of some avail to Mr. Harris and yourself, I remain, yours, etc., JOHN E. BACKUS.

MANURE IN PHILADELPHIA.

LETTER FROM JOSEPH HEACOCK.

JENKINTOWN, Montgomery Co., Pa., April 18th, 1876.

MY DEAR FRIEND HARRIS.—Stable-manure in Philadelphia, costs by the single four-horse-load, about $9 or $10. Mostly, the farmers who haul much of it, have it engaged by the year, and then it can be had for from $7 to $8 per load. Mostly, four horses are used, though we frequently see two and three-horse teams, and occasionally, five or six horses are used. I have never seen any kind of dung hauled but that of horses. Cow-manure would be thought too heavy to haul so long a distance. Sugar-house waste, spent hops, glue waste, etc, are hauled to a small extent. We live about 9 miles from the center of the city, and the road is very hilly, though otherwise a good one, being made of stone.

The loads vary from 2½ to 3½ or 4 tons for four horses, according to the dryness of the manure. The wagons are made very strong, and weigh from 1,600 lbs. to 2,300 or 2,400 lbs., according to the number of horses that are to be used to them. I cannot say how many cords there are in an average load, but probably not less than two cords to four horses. One of my neighbors has a stable engaged by the year. He pays $2.50 per ton, and averages about three tons per load, and the distance from the stable in the city to his place, can not be less than 12 miles. His team goes empty one way and of course can not haul more than a load a day. In fact, can not average that, as it would be too hard on his horses. The horses used for the purpose are large and strong. Fifteen or twenty years ago, there was kept on most farms of 75 to 100 acres, a team purposely for hauling manure from the city. But it is different now, many of the farmers using artificial manures, as it costs so much less; and others are keeping more stock, and so making their own manure. Still, there is a great deal hauled yet. And some of it to a distance of 20 miles. Though when hauled to this distance, the teams are loaded both ways. For instance, they will start to the city with a load of hay (35 to 50 cwt.), on Monday afternoon (Tuesday is the day of the Hay Market); and when they have their load of hay off on Tuesday, they load their manure and drive out five or six miles and put up for the night. Next morning they start about 3 o'clock, arriving home before noon, having been away two days. On Thursday afternoon, they start again. You can see that manuring in this way is very expensive. But farmers about here well know that if they do not manure well they raise but little. Probably about four loads are used per acre on the average. Each load is generally thrown off the wagon in one large heap near where wanted, and is allowed to lie until they use it. I can not tell how much it loses in bulk by lying in the heap.

As to what crops it is used on, farmers do not think that they could go amiss in applying it to anything except oats. But it is probably used more for top-dressing mowing land, and for potatoes, than for anything else.

The usual rotation is corn, potatoes, or oats, wheat seeded to clover and timothy, and then kept in grass from two to four years. Those who haul stable-manure, usually use bone-dust or superphosphate to a greater or less extent.

Last December I built a pig-pen, 20 ft. x 40 ft., 1½ stories high. The upper story to be used for litter, etc. There is a four feet entry on the north side, running the length of the building. The remainder is divided into five pens, each 8 ft. x 16 ft. It is made so that in cold weather it can be closed up tight, while in warmer weather it can be made as open as an out-shed. I am very much pleased with it. The pigs make a great deal of manure, and I believe that it can be made much cheaper than it can be bought and hauled from Philadelphia.

JOSEPH HEACOCK, JR.

LETTER FROM HERMAN L. ROUTZAHN.

MIDDLETOWN, Md., May 11th, 1876.

Joseph Harris, Esq.:

I herewith proceed to answer questions asked.

Wheat and corn are principal crops. Corn is fed now altogether to stock for the manure.

There is but little soiling done. The principal method of making manure is: Feeding all the corn raised, as well as hay, oats, and roots, to cattle; using wheat straw, weeds, etc., as bedding, throwing the manure in the yard (uncovered), and to cover the pile with plaster (by sowing broadcast), at least once a week. To this pile is added the manure from the hog-pens, hen-house, etc., and worked over thoroughly at least twice before using. It is then applied to corn by plowing *under*; to wheat, as a top-dressing. For corn it is usually hauled to the field, thrown off in heaps 25 feet each way, a cart-load making two heaps. Spread just before the plow. For wheat, spread on directly after plowing, and thoroughly harrowed in. Applied broadcast for potatoes. Composts of different kinds are made and used same as in other localities, I presume. Artificial manures are going into disrepute (justly too). This is the plan now adopted by the farmers in this county (Frederick). Where woods are accessible, leaves and mould are hauled in and added to the manure-heap; in fact, every substance that can be worked into the manure-heap is freely used. Well-rotted stable-manure is worth from $1.50 to $2.50 per cord, according to condition and locality.

Very Respectfully Yours,

HERMAN L. ROUTZAHN.

LETTER FROM PROF. E. M. SHELTON, PROF. OF AGRICULTURE, KANSAS STATE AGRICULTURAL COLLEGE.

KANSAS STATE AGRICULTURAL COLLEGE,
MANHATTAN, Kansas, May 5, 1876.

DEAR SIR.—In reply to your first question, I would say that stable-manure in this vicinity, is held in very light estimation. Indeed, by the householders of this city, and quite generally by the farmers, manure is regarded as one of those things—like drouth and grasshoppers—with which a mysterious Providence sees fit to clog the operations of the husbandman. The great bulk of the stable-manure made in this city is, every spring, carted into ravines and vacant lots—wherever, in short, with least expense it can be put out of reach of the senses.

It must not be understood by this that manure has little influence on the growing crops in Kansas. Nowhere have I seen such excellent results from application of home-made fertilizers, as in Kansas. For those sterile wastes known as "Alkali lands," and "Buffalo wallows," manure is a speedy and certain cure. During two years of severe drouth, I have noticed that wherever manure had been supplied, the crop withstood the effects of dry weather much better than where no application had been made. Four years ago, a strip across one of our fields was heavily manured; this year this field is into wheat, and a dark band that may be seen half a mile shows where this application was made.

These facts the better class of our farmers are beginning to appreciate. A few days ago, a neighbor, a very intelligent farmer, assured me that from manuring eight to ten acres every year, his farm was now in better condition than when be broke up the prairie fifteen years ago.

I know of no analysis of stable or farmyard-manure made in Kansas. Concerning the *weight* of manures, I can give you a few facts, having had occasion during the past winter to weigh several loads used for experimental purposes. This manure was wheeled into the barnyard, chiefly from the cattle stalls, during the winter of 1874–5. It lay in the open yard until February last, when it was weighed and hauled to the fields. I found that a wagon-box, 1½ x 3 x 9 feet, into which the manure was pitched, without treading, held with slight variations, when level full, one ton. At this rate a cord would weigh very close to three tons.

The greatest difficulty that we have to encounter in the management of manure grows out of our dry summers. During our summer months, unless sufficient moisture is obtained, the manure dries out rapidly, becomes fire-fanged and practically worthless. My practice upon the College farm has been to give the bottom of the barn-yard a "dishing" form, so that it holds all the water that falls upon it. The manure I keep as flat as possible, taking pains to place it where the animals will keep it trod down solid. I have adopted this plan after having tried composting and piling the manure in the yards, and am satisfied that it is the only *practical* way to manage manures in this climate.

There is no particular crop to which manure is generally applied in this State, unless, perhaps, wheat. The practice of applying manure as a top-dressing to winter-wheat, is rapidly gaining ground here. It is found that the manure thus applied, acting as a mulch, mitigates the effects of drouth, besides improving the quality of the grain.

Very Respectfully Yours,

E. M. SHELTON.

LETTER FROM PROF. W. H. BREWER, PROFESSOR OF AGRICULTURE IN SHEFFIELD SCIENTIFIC SCHOOL OF YALE COLLEGE.

SHEFFIELD SCIENTIFIC SCHOOL OF YALE COLLEGE,
NEW HAVEN, Conn., April 14th, 1876.

Joseph Harris, Esq., Rochester, N. Y.:

MY DEAR SIR.—I have made inquiries relating to "the price of stable-manure in New Haven, and how far the farmers and gardeners haul it, etc." I have not been to the horse-car stables, but I have to several *livery* stables, and they are all essentially the same.

They say that but little is sold by the *cord* or *ton*, or by any weight or measure. It is sold either "in the lump," "by the month," "by the year," or "per horse." Some sell it at a given sum per month for all their horses, on a general estimate of their horses—thus, one man says, "I get, this year, $25 per month for all my manure, he to remove it as fast as it accumulates; say one, two, or three times per week. He hauls it about five miles and composts it all before using."

Another says, he sells *per horse.* "I get, this year, $13 per horse, they to haul it." The price per horse ranges from $10 to $15 per year, the latter sum being high.

From the small or private stables, the manure is generally "lumped" by private contract, and is largely used about the city. It is hauled sometimes as much as 10 miles, but usually much less.

But the larger stables often sell per shipment—it is sent by cars up the Connecticut Valley to Westfield, etc., where it is often hauled several miles from the railroad or river.

Much manure is sent by boat from New York to the Connecticut Valley tobacco lands. Boats ("barges") are even loaded in Albany, go down the Hudson, up the Sound to Connecticut, to various places near Hartford, I am told. Two or three years ago, a man came here and exhibited to us pressed masses of manure—a patent had been taken out for pressing it, to send by R. R. (stable manure). I never heard anything more about it—and he was confident and enthusiastic about it.

Yours truly, WM. H. BREWER.

FOOD, INCREASE, MANURE, ETC., OF FATTENING ANIMALS.

The following table is given by Mr. J. B. Lawes, of Rothamsted, England, showing the relation of the increase, manure, and loss by respiration, to the food consumed by different animals:

OXEN.

	250 lbs. Oil-cake; 600 " Clover-chaff. 3500 lbs. Swede turnips and supply. — *Produce, 100 lbs. Increase.*				*100 Total Dry Substance of Food supply.*			*Amount of each constituent stored up for 100 of it consumed.*
	In Food	In 100 lbs. Increase.	In Manure.	In Respiration etc.	In Increase.	In Manure.	In Respiration etc.	
	lbs.	lbs.	lbs.	lbs.				
Nitrogenous substance.	218	9.0			0.8			4.1
Non-Nitrogenous substance................	808	58.0	323.0	636	5.2	29.1	57 3	7.2
Mineral Matter.........	83	1.6	81.4	...	0.2	7.4	...	1.9
Total dry substance....	1109	68.6	404.4	636	6.2	36.5	57.3	...

SHEEP.

	250 lbs. Oil-cake; 300 " Clover-chaff. 4000 lbs. Swede turnips and supply. — *Produce. 100 lbs. Increase.*				*100 Total Dry Substance of Food supply.*			*Amount of each constituent stored up for 100 of it consumed.*
	In Food	In 100 lbs. Increase.	In Manure.	In Respiration etc.	In Increase.	In Manure.	In Respiration etc.	
	lbs.	lbs.	lbs.	lbs.				
Nitrogenous substance.	177	7.5			0.8			4.2
Non-Nitrogenous substance................	671	63.0	229	548.5	7.0	25.1	60.1	9.4
Mineral matter.........	64	2.0	62	....	0.2	6.8	...	3.1
Total dry substance....	912	72.5	291	548.5	8.0	31.9	60.1	...

PIGS.

	500 lbs. Barley meal produce 100 lbs. increase, and supply.				*100 Total Dry Substance of Food supply.*			*Amount of each constituent stored up for 100 of it consumed.*
	In Food.	In 100 lbs. Increase.	In Manure.	In Respiration, etc.	In Increase.	In Manure.	In Respiration, etc.	
	lbs.	lbs.	lbs.	lbs.				
Nitrogenous substance.	52	7.0			1.7			13.5
Non-Nitrogenous substance................	357	66.0	59.8	276.2	15.7	14.3	65.7	18.5
Mineral matter.........	11	0.8	10 2	....	0.2	2.4	...	7.3
Total dry substance....	420	73.8	70.0	276.2	17.6	16.7	65.7	......

In the last edition of his book on Manure, "Praktische Düngerlehre," Dr. Emil Wollf, gives the following tables:

Of 100 lbs. of *dry substance* in the food, there is found in the excrements:

Dry Substance.	*Cow.*	*Ox.*	*Sheep.*	*Horse.*	*Mean.*
In the Dung	38.0 lbs.	45.6 lbs.	46.9 lbs.	42.0 lbs.	43.1 lbs.
In the Urine	9.1 "	5.8 "	6.6 "	3.6 "	6.3 "
Total dry substance in the Manure	47.1 "	51.4 "	53.5 "	45.6 "	49.4 "

Of 100 lbs. of *organic substance* in the food, there is found in the excrements:

Organic Substance.	*Cow.*	*Ox.*	*Sheep.*	*Horse.*	*Mean.*
In the Dung	36.5 lbs.	43.9 lbs.	45.6 lbs.	38.2 lbs.	41.0 lbs.
In the Urine	6.0 "	3.2 "	3.9 "	2.5 "	3.9 "
Total organic substance in Manure	42.5 "	47.1 "	49.5 "	40.7 "	44.9 "

Of 100 lbs. of *nitrogen* in the food, there is found in the excrements:

Nitrogen.	*Cow.*	*Ox.*	*Sheep.*	*Horse.*	*Mean.*
In the Dung	45.5 lbs.	51 0 lbs.	43.7 lbs.	56.1 lbs.	49.1 lbs.
In the Urine	18.3 "	38.6 "	51.8 "	27.3 "	34.0 "
Total Nitrogen in Manure	63.8 "	89.6 "	95.5 "	83.4 "	83.1 "

Of 100 lbs. *mineral matter* in the food, there is found in the excrements:

Mineral Matter.	*Cow.*	*Ox.*	*Sheep.*	*Horse.*	*Mean.*
In the Dung	53.9 lbs.	70.8 lbs.	63.2 lbs.	85.6 lbs.	68.4 lbs.
In the Urine	43.1 "	46.7 "	40.3 "	16.3 "	35.1 "
Total mineral matter in Manure	97.0 "	117.5 "	103.5 "	101.9 "	103.5 "

The excess of mineral matter is due to the mineral matter in the water drank by the animals.

The following tables of analyses are copied in full from the last edition (1875), of Dr. Emil Wolff's *Praktische Düngerlehre.*

The figures differ materially in many cases from those previously published. They represent the average results of numerous reliable analyses, and are sufficiently accurate for all practical purposes connected with the subject of manures. In special cases, it will be well to consult actual analyses of the articles to be used.

I.—TABLES FOR CALCULATING THE EXHAUSTION AND ENRICHING OF SOILS.

A.—HARVEST PRODUCTS AND VARIOUS MANUFACTURED ARTICLES.

Average quantity of water, nitrogen, and total ash, and the different ingredients of the ash in 1000 lbs. of fresh or air-dried substance.

SUBSTANCE.	*Water.*	*Nitrogen.*	*Ash.*	*Potash.*	*Soda.*	*Lime.*	*Magnesia.*	*Phosphoric Acid.*	*Sulphuric Acid.*	*Silica and Sand.*
I.—HAY.										
Meadow Hay........ ..	143	15.5	51.5	13.2	2.3	8.6	3.3	4.1	2.4	13.9
Rye Grass..............	143	16.3	58.2	20.2	2.0	4.3	1.3	6.2	2.3	18.5
Timothy.......	143	15.5	62.1	20.4	1.5	4.5	1.9	7.2	1.8	22.1
Moharhay..............	134	17.5	58.4	21.2	1.2	6.1	5.4	3.4	2.1	16.3
Red Clover..............	160	19.7	56.9	18.3	1.2	20.0	6.1	5.6	1.7	1.4
Red Clover, ripe.......	150	12.5	44.0	9.8	1.4	15.6	6.8	4.3	1.3	3.0
White Clover..........	165	23.2	59.8	10.1	4.5	19.3	6.0	8.4	4.9	2.5
Alsike Clover....	160	24.0	39.7	11 0	1.2	13.5	5.0	4.0	1.6	1.6
Crimson Clover........	167	19.5	50.7	11.7	4.3	16.0	3.1	3.6	1.3	8.2
Lucern....................	160	23.0	62.1	15.3	1.3	26.2	3.3	5.5	3.7	3.8
Esparsette......... . ..	167	21.3	45.8	13.0	1.5	16.8	3.0	4.6	1.4	3.7
Yellow Clover..........	167	22.1	55.7	11.9	1.3	32.6	2.1	4.3	1.0	1.5
Green Vetch Hay.......	167	22.7	83.7	28.3	5.6	22.8	5.4	10.7	2.8	4.9
Green Pea Hay........	167	22.9	62.4	23.2	2.3	15.6	6.3	6.8	5.1	0.9
Spurry...	167	19.2	56.8	19.9	4.6	10.9	6.9	8.4	2.0	0.8
II.—GREEN FODDER.										
Meadow Grass in bloom	700	5.4	18.1	4.6	0.8	3.0	1.1	1.5	0.8	4.9
Young Grass..........	800	5.6	20.7	11.6	0.4	2.2	0.6	2.2	0.8	2.1
Rye Grass	734	5 7	20.4	7.2	0.7	1.5	0.4	2 2	0.8	6.5
Timothy Grass	700	5.4	21.6	7.4	0.5	1.6	0.7	2.5	0.6	7.7
Rye-Fodder	760	5.3	16.3	6.3	0.1	1.2	0.5	2.4	0.2	5.2
Green Oats............	810	3.7	18.8	7.5	0.6	1.2	0.6	1.7	0.6	5.7
Green Corn-Fodder....	822	1.9	12.0	4.3	0.5	1.6	1.4	1.3	0.4	1.7
Sorghum...	773	4.0	13.0	3.6	1.8	1.2	0.5	0.8	0.4	3.7
Moharhay	700	5.9	13.9	5.0	0.3	1.4	1.3	0.8	0.5	3.9
Red Clover in blossom	780	5.1	13.7	4.4	0.3	4.8	1.5	1.4	0.4	0.3
" " before "	830	5.3	14.5	5.3	0.3	4.2	1.5	1.7	0.3	0.4
White Clover.........	805	5.6	13.6	2.3	1.0	4.4	1.4	1.9	1.1	0.6
Alsike Clover	820	5.3	8.8	2.4	0.3	3.0	1.1	0.9	0.4	0.4
Crimson Clover........	815	4.3	12.2	2.8	1.0	3.8	0.7	0.9	0.3	2.0
Lucern..................	740	7.2	18.7	4.6	0.4	7.9	1.0	1.6	1.1	1.1
Esparsette	800	5.1	12.1	3.4	0.4	4.4	0.8	1.2	0.4	1.0
Yellow Clover...	830	4.5	14.7	3.2	0.3	8.6	0.6	1.1	0.3	0.4
Green Vetch...........	820	5.6	18.1	6.1	1.2	4.9	1.2	2.3	0.6	1.1
Green Peas............	815	5.1	13.9	5.1	0.5	3.5	1.4	1.5	1.1	0.2
Green Rape............	870	4.6	12.2	4.0	0 4	2.7	0.5	1.4	1.7	0.6
Spurry..................	800	3.7	12 2	4.3	1.0	2.3	1.5	1.8	0.4	0.2
III.—ROOT CROPS.										
Potatoes...............	750	3.4	9.4	5.7	0.2	0.2	0.4	1.6	0.6	0.2
Jerusalem Artichoke...	800	3.2	9.8	4.7	1.0	0.3	0.3	1.4	0.5	1.0
Mangel-wurzel.........	880	1.8	7.5	4.1	1.2	0.3	0.3	0.6	0.2	0.2
Sugar Beets............	815	1.6	7.1	3.9	0.7	0.4	0.5	0.8	0.3	0.1
Turnips.................	920	1.8	7.3	3.3	0.7	0.8	0.3	0.9	0.8	0.1
Carrots.......	850	2.2	7.8	2.8	1.7	0.9	0.4	1.0	0.5	0.2
Russia Turnips........	870	2.1	11.6	4.7	1.2	1.3	0.3	1.7	1.5	0.1
Succory.................	800	2.5	6.7	2.6	1.1	0.5	0.3	0.8	0.5	0.3
Sugar Beet, upper part of root..............	840	2.0	9.6	2.8	2.3	0.9	1.1	1.2	0.7	0.2

SUBSTANCE.	*Water.*	*Nitrogen.*	*Ash.*	*Potash.*	*Soda.*	*Lime.*	*Magnesia.*	*Phosphoric Acid.*	*Sulphuric Acid.*	*Silica and Sand.*
IV.—LEAVES & STEMS OF ROOT CROPS.										
Potato Vines, nearly ripe....	770	4.9	19.7	4.3	0.4	6.4	3.3	1.6	1.3	0.9
Potato Vines, unripe.	825	6.3	16.5	4.4	0.3	5.1	2.4	1.2	0.8	1.2
Jerusalem Artichoke.	800	5.3	14.5	3.1	0.2	5.0	1.3	0.7	0.2	3.6
Mangel-wurzel.......	905	3.0	14.1	4.1	2.9	1.6	1.3	0.8	0.8	0.5
Sugar Beets	897	3.0	18.1	6.5	2.7	2.7	2.7	1.3	0.9	0.7
Turnips	898	3.0	11.9	2.8	1.1	3.9	0.5	0.9	1.1	0.5
Carrots........... ..	822	5.1	26.0	2.9	5.2	8.5	0.9	1.2	2.0	2.9
Succory..............	850	3.5	16.5	4.3	2.9	3.2	0.4	1.0	1.4	0.6
Russia Turnips......	850	4.6	25.3	3.7	1.0	8.4	1.0	2.6	3.0	2.6
Cabbage, white......	890	2.4	16.0	6.3	0.9	3.1	0.6	1.4	2.4	0.2
Cabbage Stems......	820	1.8	11.6	5.1	0.6	1.3	0.5	2.4	0.9	0.2
V.—MANUFACTURED PRODUCTS & REFUSE.										
Wheat Bran..........	131	22.4	53.5	14.3	0.2	1.7	8.8	27.3	0.1	0.5
Rye Bran........... .	125	23.2	71.4	19.3	1.0	2.5	11.3	34.3	...	1.4
Barley Bran..........	120	23.7	48.4	8.1	0.7	1.8	3.0	8.9	0.9	23.6
Oat Hulls............	140	...	34.7	4.9	0.3	1.4	1.0	1.6	1.3	23.3
Pea Bran.....	140	...	22.7	10.3	0.2	4.1	2.2	3.1	0.9	0.9
Buckwheat Bran.....	140	27.2	34.6	11.2	0.7	3.4	4.6	12.5	1.0	0.7
Wheat Flour..........	136	18.9	7.2	2.6	0.1	0.2	0.4	3.7	...	...
Rye Flour.	142	16.8	16.9	6.5	0.3	0.2	1.4	8.5	...	...
Barley Meal.....	140	16.0	20.0	5.8	0.5	0.6	2.7	9.5	0.6	...
Corn Meal...........	140	16.0	5.9	1.7	0.2	0.4	0.9	2.6	...	...
Green Malt...........	475	10.4	14.6	2.5	...	0.5	1.2	5.3	...	4.8
Dry Malt	75	16.0	26.6	4.6	...	1.0	2.2	9.7	...	8.8
Brewer's Grains......	766	7.8	11.7	0.5	0.1	1.3	1.0	4.1	...	4.6
Beer..................	900	...	6.2	2.1	0.6	0.2	0.4	2.0	0.2	0.6
Malt-sprouts.........	80	36.8	66.7	20.6	1.2	1.9	1.8	18.0	2.9	14.7
Potato Fibre.........	850	1.3	1.8	0.3	...	0.9	0.1	0.4	...	0.1
Potato Slump........	948	1.6	5.0	2.2	0.4	0.3	0.4	1.0	0.4	0.2
Sugar-beet Pomace...	700	2.9	11.4	3.9	0.9	2.6	0.7	1.1	0.4	0.9
Clarifying Refuse....	948	0 8	3.3	0.3	0.1	1.1	0.2	0.2	0.1	0.7
Sugar-beet Molasses.	172	12.8	82.3	57.5	10.0	4.7	0.3	0.5	1.7	0.3
Molasses Slump......	920	3.2	14.0	11.0	1.5	0.2	...	0.1	0.2	...
Rape-cake........... ..	150	48.5	54.6	12.4	1.8	6.8	7.0	19.2	3.2	2.8
Linseed Oil-cake.....	115	45.3	50.8	12.4	0.7	4.3	8.1	16.1	1.6	6.4
Poppy-cake.	100	52.0	76.9	2.3	2.3	27.0	6 2	31.2	1.9	4.5
Beech-nut-cake..... ..	100	38.1	43.3	6.5	4.6	13.2	3.6	9.7	0.6	0.8
Walnut-cake.........	137	55.3	46.2	14.3	...	3.1	5.6	20.2	0.6	0.7
Cotton-seed-cake	115	39.0	58.4	14.6	...	2.7	8.9	28.1	0.7	2.3
Cocoanut-cake.......	127	37.4	55.1	22.4	1.3	2.6	1.6	14.9	2.1	1.9
Palm-oil-cake...... ..	100	25.9	26.1	5.0	0.2	3.1	4.5	11.0	0.5	0.8
VI.—STRAW.										
Winter Wheat........	143	4.8	46.1	6.3	0.6	2.7	1.1	2.2	1.1	31.2
Winter Spelt..... ...	143	4 0	50.1	5.2	0.3	2.9	1.2	2.6	1.2	36.0
Winter Rye..........	143	4.0	40.5	7.8	0 9	3.5	1.1	2.1	1.1	22.9
Spring Wheat........	143	5.6	38.1	11.0	1.0	2.6	0.9	2.0	1.2	18.2
Spring Rye..........	143	5.6	46.6	11.2	...	4.2	1.8	3.0	1.2	26.1
Barley	143	6.4	41.3	9.4	1.7	3.2	1.1	1.9	1.5	21.5
Oats..................	143	5.6	40.4	8.9	1.2	3.6	1.6	1.9	1.3	19.6
Indian Corn-stalks...	150	4.8	41.9	9.6	6.1	4.0	2.6	5.3	1.2	11.7
Buckwheat Straw	160	13.0	51.7	24.2	1.1	9.5	1 9	6.1	2.7	2.9
Pea Straw	160	10.4	44.0	10.1	1.8	16.2	3.5	3.5	2.7	3.0
Field Bean...........	160	16.3	43.9	18.5	1.1	9.8	3.3	3.2	1.6	3.2
Garden Bean.........	160	...	40.0	12.8	3.2	11.1	2.5	3.9	1.7	1.9
Common Vetch......	160	12.0	44.1	6.3	6.9	15.6	3.7	2.7	3.3	3.6

SUBSTANCE.	*Water.*	*Nitrogen.*	*Ash.*	*Potash.*	*Soda.*	*Lime.*	*Magnesia.*	*Phosphoric Acid.*	*Sulphuric Acid.*	*Silica and Sand.*
Lupine	160	9.4	41.4	8.0	2.6	14.8	3.6	3.7	3.0	2.1
Rape	160	5.6	40.8	11.1	3.8	11.6	2.5	2.4	3.1	2.6
Poppy	160	...	48.7	18.4	0.6	14.7	3.1	1.6	2.5	5.5
VII.—CHAFF.										
Winter Wheat	143	7.2	92.5	8.5	1.7	1.8	1.2	4.0	...	75.1
Spring Wheat	143	7.5	121.4	4.8	1.0	4.0	1.5	3.1	0.7	105.3
Winter Spelt	143	5.6	82.7	7.9	0.2	2.0	2.1	6.1	1.9	61.3
Winter Rye	143	5.8	84.0	5.3	0.3	3.5	1.2	5.6	0.1	69.2
Barley Awns	143	4.8	120.0	9.4	1.2	12.7	1.6	2.4	3.7	86.6
Oats	143	6.4	71.2	4.6	2.9	4.0	1.5	1.3	3.5	50.4
Indian Corn-cobs	140	2.3	4.6	2.4	0.1	0.2	0.2	0.2	0.1	1.3
Field Beans	150	16.8	54.5	35.3	1.3	6.8	5.9	2.7	1.2	0.3
Lupine	143	7.2	18.1	8.7	0.7	3.6	1.5	1.1	0.5	0.9
Rape	140	6.4	73.2	11.8	4.4	36.3	4,2	3.4	7.3	1.0
Flax-seed hulls	120	...	54.7	15.4	3.0	15.4	3.3	4.5	3.4	5.0
VIII.—COMMERCIAL PLANTS, ETC.										
Flax Stems	140	...	30.4	9.4	2.5	6.8	2.0	4.0	2.0	1.7
Rotted Flax Stems	100	...	7.0	0.3	0.2	3.6	0.2	0.8	0.2	1.3
Flax Fibre	100	...	6.8	0.3	0.3	3.6	0.3	0.7	0.3	0.8
Hemp Stems	150	...	33.2	4.6	0.7	20.3	2.4	2.3	0.7	3.5
Hops, entire plant	140	...	81.4	20.1	2.8	18.1	6.4	7.5	3.7	16.4
Hops	120	...	66.8	23.0	1.4	11.1	3.7	11.2	2.4	11.1
Hop Stems	160	...	40.7	11.4	1.7	12.6	2.7	4.4	1.3	3.4
Tobacco Leaves	180	...	151.0	30.3	5.1	62.8	17.7	4.8	5.8	13.5
Wine and Must	866	...	2.1	1.3	...	0.1	0.1	0.4	0.1	...
Wine-grounds	650	...	13.9	6.1	0.2	2.9	0.7	2.5	0.6	0.2
Grape Stems, etc	550	...	13.0	4.0	1.4	4.5	0.7	1.6	0.3	0.2
Mulberry Leaves	850	...	16.3	3.9	0.2	5.4	1.0	1.3	0.3	4.1
IX.—MATERIALS FOR BEDDING.										
Reed	180	...	36.7	6.8	0.2	3.3	1.1	2.3	0.6	20.0
Sedge Grass	140	...	61.2	17.7	4.9	4.2	2.9	4.6	2.3	20.3
Rush	140	...	48.1	19.0	3.1	3.6	3.1	4.3	1.3	6.8
Beech Leaves, August	560	...	19.0	3.7	0.4	6.4	1.4	1.8	0.4	3.8
" " Autumn	150	8.0	58.5	2.3	0.4	26.4	3.5	2.4	2.1	19.7
Oak Leaves, August	550	...	15.8	5.4	...	4.1	2.1	1.9	0.4	0.7
" " Autumn	150	8.0	41.7	1.4	0.3	20.3	1.7	3.5	1.8	12.9
Fir Needles	475	5.0	18.4	1.0	0.3	6.1	1.1	1.0	0.4	6.3
Pine "	450	...	32.0	0.6	0.1	4.3	0.5	1.4	0.6	22.6
Moss	250	...	19.2	2.6	1.6	2.2	1.1	0.9	1.0	5.5
Fern	250	...	50.7	18.0	2.1	6.2	3.5	4.2	1.8	10.3
Heath	200	10.0	16.6	2.1	1.1	3.6	1.6	1.1	0.7	4.9
Broom	250	...	13.6	4.8	0.3	2.2	1.6	1.1	0.4	1.3
Sea-Weed	150	14.0	122.3	15.9	28.1	16.7	10.0	3.8	26.3	2.5
X.—GRAINS AND SEEDS.										
Winter Wheat	144	20.8	16.9	5.3	0.4	0.6	2.0	7.9	0.1	0.4
Spring Wheat	143	20.5	18.3	5.5	0.4	0.5	2.2	8.9	0.3	0.3
Spelt, without husk	143	22.0	14.2	5.1	0.5	0.4	1.7	6.0	...	0.2
Spelt, with husk	148	16.0	36.6	5.7	0.4	1.0	2.4	7.6	1.1	17.1
Winter Rye	143	17.6	17.9	5.6	0.3	0.5	2.1	8.4	0.2	0.4
Winter Barley	145	16.0	17.0	2.6	0.7	0.2	2.1	5.6	0.5	4.9
Spring Barley	143	16.0	22.2	4.5	0.6	0.6	1.9	7.7	0.4	6.1
Oats	143	19.2	27.0	4.4	0.6	1.0	1.9	6.2	0.4	12.8
Millet	140	20.3	29.8	3.4	0.4	0.2	2.9	5.9	0.1	15.8
Indian Corn	144	16.0	13.0	3.7	0.2	0.3	2.0	5.9	0.2	0.2

SUBSTANCE.	*Water.*	*Nitrogen.*	*Ash.*	*Potash.*	*Soda.*	*Lime.*	*Magnesia.*	*Phosphoric Acid.*	*Sulphuric Acid.*	*Silica and Sand.*
Sorghum	140	...	16.0	3.3	0.5	0.2	2.4	8.1	...	1.2
Buckwheat	140	14.4	11.8	2.7	0.7	0.5	1.5	5.7	0.2	0.1
Peas	143	35.8	23.5	9.8	0.2	1.2	1.9	8.6	0.8	0.2
Field Beans	145	40 8	30.7	13.1	0.4	1.5	2.2	11.9	0.8	0.2
Garden Beans	150	39.0	27.4	12.0	0.4	1.8	2.0	9.7	1.1	0.2
Vetch	143	44.0	26.8	8.1	2.1	2.1	2.4	10.0	1.0	0.3
Lupine	130	56.6	34.1	10.2	0.1	3 0	4.0	14.3	1.5	0.2
Red Clover	150	30.5	38.3	13.5	0.4	2.5	4.9	14.5	0.9	0.5
White Clover	150	...	33.8	12.3	0.2	2.5	3.9	11 6	1.6	0.8
Esparsette	160	...	38.4	11.0	1.1	12.3	2.6	9.2	1.2	0.3
Ruta-bagas	140	...	48.8	9.1	8.5	7.6	8.6	7.6	2.1	1.1
Sugar-Beet	146	...	45.3	11.1	4.2	10.2	7 3	7.5	2.0	0.8
Carrots	120	...	74 8	14.3	3.5	29.1	5.0	11.8	4.2	4.0
Succory	130	...	54.6	6.5	4.6	17.3	5.9	16.5	2 4	0.6
Turnips	125	...	34.6	7.6	0.4	6.1	3.1	14.0	2.5	0.2
Rape	118	31.2	39.1	9.6	0.6	5.5	4.6	16.5	0.9	0.5
Summer-Rape	120	...	34.9	7.7	...	5.2	4.7	14.9	2.3	...
Mustard	130	...	36.5	5.9	2.0	7.0	3.7	14.6	1.8	0.9
Poppy	147	28.0	52.9	7.2	0.5	18.7	5 0	16.6	1.0	1.7
Linseed	118	32.8	32.6	10.0	0.7	2.6	4.7	13.5	0 8	0.4
Hemp	122	26.1	45.3	9.4	0.4	10.9	2.6	16.9	0.1	5.5
Grape-seeds	110	...	25.0	7.2	...	8.4	2.1	6.0	0.6	0.3
Horse-chestnuts, fresh	492	10.2	12.0	7.1	...	1.4	0.1	2.7	0.3	0 3
Acorns, fresh	550	...	9.6	6.2	0.1	0.7	0.5	1.4	0.4	0.1
XI.—VARIOUS ANIMAL PRODUCTS.										
Cows' Milk	875	5.1	6.2	1.5	0.6	1.3	0.2	1.7	...	...
Sheep "	860	5.5	8.4	1.8	0.3	2.5	0.1	3.0	0.1	0 2
Cheese	450	45.3	67.4	2.5	26.6	6.9	0.2	11.5	...	...
Ox-blood	790	32.0	7.5	0.6	3.4	0.1	0.1	0 4	0.2	0.1
Calf-blood	800	29.0	7.1	0.8	2.9	0.1	0.1	0.6	0.1	...
Sheep-blood	790	32.0	7.5	0.5	3.3	0.1	0 1	0.4	0.1	...
Swine-blood	800	29.0	7.1	1.5	2.2	0.1	0.1	0.9	0.1	...
Ox-flesh	770	36.0	12.6	5 2	...	0.2	0.4	4.3	0.4	0.3
Calf flesh	780	34.9	12.0	4.1	1.0	0.2	0.2	5.8	..	0.1
Swine-flesh	740	34.7	10.4	3.9	0.5	0.8	0.5	4 6	...	0.1
Living Ox	597	26.6	46.6	1.7	1.4	20.8	0.6	18.6	...	0.1
Living Calf	662	25.0	38.0	2 4	0.6	16.3	0.5	13.8	...	0.1
Living Sheep	591	22.4	31.7	1.5	1.4	13.2	0.4	12.3	...	0.2
Living Swine	528	20 0	21.6	1.8	0.2	9.2	0.4	8.8	...	...
Eggs	672	21 8	61.8	1.5	1.4	54.0	1.0	3.7	0.1	0.1
Wool, washed	120	94.4	9 7	1.8	0.3	2.4	0.6	0.3	...	2.5
Wool, unwashed	150	54.0	98.8	74.6	1.9	4.2	1.6	1.1	4.0	3 0

B.—AVERAGE COMPOSITION OF VARIOUS MANURES.

NAME OF FERTILIZER.	*Water.*	*Organic Substance.*	*Ash.*	*Nitrogen.*	*Potash.*	*Soda.*	*Lime.*	*Magnesia.*	*Phosphoric Acid.*	*Sulphuric Acid.*	*Silica and Sand.*	*Chlorine and Florine.*
I.—ANIMAL EXCREMENTS.												
(In 1000 parts of Manure.)												
Fresh Fæces:												
Horse	757	211	31.6	4.4	3.5	0.6	1.5	1.2	3.5	0.6	19.6	0.2
Cattle	838	145	17.2	2.9	1.0	0.2	3.4	1.3	1.7	0.4	7.2	0.2
Sheep	655	314	31.1	5.5	1.5	1.0	4 6	1.5	3.1	1.4	17.5	0.3
Swine	820	150	30.0	6.0	2.6	2.5	0.9	1.0	4.1	0.4	15.0	0.3
Fresh Urine:												
Horse	901	71	28.0	15.5	15 0	2.5	4 5	2.4	..	0 6	0.8	1 5
Cattle	938	35	27.4	5.8	4.9	6.4	0.1	0.4	..	1.3	0 3	3.8
Sheep	872	83	45.2	19.5	22 6	5.4	1.6	3.4	0.1	3 0	0 1	6.5
Swine	967	28	15.0	4.3	8.3	2 1	..	0.8	0.7	0.8	..	2.3
Fresh Dung (with straw:)*												
Horse	713	254	32.6	5.8	5.3	1.0	2.1	1.4	2.8	0.7	17.7	0.4
Cattle	775	203	21.8	3.4	4.0	1.4	3.1	1.1	1.6	0.6	8.5	1.0
Sheep	646	318	35.6	8.3	6.7	2.2	3.3	1.8	2.3	1.5	14.7	1.7
Swine	724	250	25.6	4.5	6.0	2 0	0.8	0.9	1.9	0.8	10.8	1.7
Common Barn-yard Manure:												
Fresh	710	246	44.1	4 5	5.2	1.5	5.7	1.4	2.1	1.2	12.5	1.5
Moderately rotted	750	192	5o.0	5.0	6.3	1.9	7.0	1.8	2 6	1.6	16.8	1.9
Thoroughly rotted	790	145	65.0	5.8	5.0	1 3	8.8	1.8	3.0	1.3	17.0	1.6
Drainage from Barn-yard Manure	982	7	10.7	1.5	4.9	1.0	0.3	0.4	0.1	0.7	0.2	1.2
Human Fæces, fresh.	772	198	29.9	10.0	2.5	1.6	6.2	3.6	10.9	0.8	1.9	0.4
" Urine, "	963	24	13 5	6.0	2 0	4 6	0.2	0.2	1.7	0.4	..	5.0
Mixed human excrements, fresh	933	51	16 0	7.0	2 1	3 .8	0.9	0.6	2.6	0.5	0.2	4.0
Mixed human excrements, mostly liquid	955	30	15 0	3.5	2.0	4 0	1.0	0.6	2.8	0.4	0.2	4.3
Dove Manure, fresh	519	308	173.0	17.6	10.0	0.7	16.0	5.0	17 8	3.3	20.2	..
Hen " "	560	255	185.0	16.3	8.5	1.0	24.0	7.4	15.4	4.5	35.2	..
Duck " "	566	262	172.0	10.0	6.2	0.5	17.0	3 5	14.0	3.5	28.0	..
Geese " "	771	134	95.0	5.5	9.5	1.3	8.4	2.0	5.4	1.4	14.0	..
II.—COMMERCIAL MANURES.												
(In 100 parts of Fertilizer.)												
Peruvian Guano	14.8	51.4	33.8	13.0	2.3	1.4	11.0	1.2	13 0	1.0	1.7	1.3
Norway Fish-Guano	12.6	53.4	34.0	9.0	0.3	0.9	15 4	0.6	13.5	0 3	1.6	1.1
Poudrette	24.0	27.0	49.0	2.0	0.9	1.0	18.6	0.5	2.1	1.0	5.4	1.5
Pulverized Dead Animals	5.7	56.9	37.4	6.5	0.3	0.8	18.2	0.4	13 9	1.0	1.7	0.2
Flesh-Meal	27.8	56.6	15.6	9.7	..	..	7.0	0.3	6.3	0.1	1.1	..
Dried Blood	14 0	79.0	7.0	11.7	0.7	0.6	0.7	0.1	1.0	0.4	2.1	0.4
Horn-Meal and Shavings	8.5	68.5	25.0	10.2	..	..	6.6	0.3	5.5	0.9	11.0	..
Bone-Meal	6.0	33.3	60.7	3.8	0.2	0.3	31.3	1 0	23.2	0.1	3.5	0.3

* It is estimated that in the case of horses, cattle, and swine, one-third of the urine drains away. The following is the amount of wheat-straw used daily as bedding for each animal. Horse, 6 lbs.; Cattle, 8 lbs.; Swine, 4 lbs., and sheep, 0.6 lbs.

NAME OF FERTILIZER.	*Water.*	*Organic Substance.*	*Ash.*	*Nitrogen.*	*Potash.*	*Soda.*	*Lime.*	*Magnesia.*	*Phosphoric Acid.*	*Sulphuric Acid.*	*Silica and Sand.*	*Chlorine and Florine.*
(In 100 parts.)	%	%	%	%	%	%	%	%	%	%	%	%
Bone-Meal from solid parts	5.0	31.5	63.5	3.5	0.1	0.2	33 0	1.0	25.2	0.1	3.0	0.2
Bone-Meal from soft parts	7.0	37.3	55.7	4.0	0.2	0.3	29.0	1.0	20.0	0.1	3.5	0.2
Bone-black, before used	6 0	10.0	84.0	1.0	0.1	0.3	43 0	1.1	32 0	0.4	5.0	..
Bone-black, spent	10.0	6.0	84.0	0.5	0.1	0.2	37.0	1.1	26.0	0 4	15.0	..
Bone ash	6.0	3.0	91.0	..	0.3	0.6	46.0	1.2	35.4	0.4	6.5	..
Baker Guano	10.0	9.2	81.0	0.5	0.2	1.2	41.5	1.5	34.8	1.5	0.8	0.3
Jarvis Guano	11.8	8.2	80.0	0.4	0.4	0.3	39.1	0 5	20.6	18.0	0.5	0.2
Estremadura Apatite	0 6	..	..	..	0.7	0.3	48.1	0.1	37.6	0.2	9.0	1.5
Sombrero Phosphate	8.5	..	91.5	0 1	..	0.8	43.5	0.6	35.0	0.5	1.0	0.6
Navassa Phosphate	2.6	5.4	92.0	0.1	..	..	37.5	0.6	33.2	0.5	5.0	0.1
Nassau Phosphorite, rich	2.6	..	97.4	..	0.8	0.4	45.1	0.2	33.0	0.3	5.5	3.1
Nassau Phosphorite, medium	2.5	..	97.5	..	0.7	0.4	40.1	0.2	24.1	..	20.8	1.5
Westphalian Phosphorite	6.5	1.6	91.8	..	..	..	21.8	0.9	19.7	1.0	22.0	1.6
Hanover Phosphorite	2.0	3.5	94.5	..	..	..	37.2	0.2	29.2	0.5	3.3	1.5
Coprolites	4.3	..	95.7	..	1.0	0.5	45.4	1.0	26.4	0 8	7.5	0.1
Sulphate of Ammonia	4.0	..	..	20.0	..	..	0.5	..	..	58 0	3.0	1.4
Nitrate of Soda	2.6	..	..	15 5	..	35.0	0.2	..	..	0.7	1.5	1.7
Wool-dust and offal	10.0	56.0	34.0	5.2	0.3	0.1	1 4	0.3	1.3	0.5	29.0	0.2
Lime-cake	6.5	47.0	46.5	3.1	..	..	20.5	2.4	3.0	..	8.0	..
Whale-oil refuse	23.0	68.4	8.6	5.7	..	..	3.0	0.2	2.3	..	3.0	..
Common Salt	5.0	..	95.0	..	..	44.3	1.2	0.2	..	1.4	2.0	48.2
Gypsum or Plaster	20.0	..	80.8	..	..	..	31.0	0.1	..	44.0	4.0	..
Gas-lime	7.0	1.3	91.7	0 4	0.2	..	64.5	1.5	..	12.5	3.0	..
Sugar-House Scum	34 5	24.5	41.0	1.2	0.2	0.6	20.7	0.3	1.5	0.3	9.1	0.1
Leached wood ashes	20.0	5.0	75.0	..	2.5	1.3	24.5	2.5	6.0	0.8	20.0	..
Wood-soot	5.0	71.8	23 2	1.3	2.4	0.5	10.0	1.5	0.4	0.3	4.0	..
Coal-soot	5.0	70 2	24 8	2.5	0.1	..	4.0	1.5	..	1.7	16.0	..
Ashes from Deciduous trees	5.0	5.0	90.0	..	10.0	2.5	30.0	5.0	6.5	1.6	18.0	0.3
Ashes from Evergreen trees	5.0	5.0	90.0	..	6.0	2.0	35.0	6.0	4.5	1.6	18.0	0.3
Peat-ashes	5.0	..	95.0	..	1.5	0.8	?	1.5	0.6	1.3	?	0.2
Bituminous coal-ashes	5.0	..	95.0	..	0.5	0.4	?	3.2	0.2	8.5	?	..
Anthracite coal-ashes	5.0	5.0	90.0	..	0.1	0.1	?	3.0	0.1	5.0	?	..
III.—SUPERPHOSPHATE, from												
Peruvian Guano	16.0	41.9	42.1	10.0	2.0	1.2	9.5	1.0	10.5	15.0	1.5	1.1
Baker Guano	15.0	6.2	78.8	0.3	0.1	0.8	25 9	0.9	21.8	28 5	0.9	0.2
Estremadura Apatite	15.0	..	85.0	..	0.4	0.2	28.2	0.1	22.1	28.5	5.3	0.9
Sombrero Phosphate	15.0	..	85.0	..	..	0.5	26 4	0.4	20 2	25.5	0.6	0.4
Navassa Phosphate	15.0	2.5	82.5	.	..	?	17.0	0.3	15 4	19.5	2 3	?
Nassau Phosphorite, rich	15.0	..	85.0	..	0.5	0.2	26.5	0.1	19.4	25.5	3.2	1.8
Nassau Phosphorite, medium	12.0	..	88.0	..	0.3	0.1	24.2	0.1	16.6	19.5	13.5	1.3
Bone-black	15.0	8.0	77.0	0 3	..	0.1	25.0	0 7	16.2	21.0	9.3	..
Bone-Meal	13.0	23.8	63.2	2.0	0.1	0.2	22.4	0.7	16.6	19.5	2.5	0.2
Phospho-guano (manufactured.)	15 5	13.0	80.3	3.3	0.3	0.4	24.0	..	20.5	28.8	3.0	0.9

2.—TABLE SHOWING THE DISTRIBUTION OF INGREDIENTS IN SOME MANUFACTURING PROCESSES.

NAME OF MATERIAL.	Dry Substance.	Nitrogen.	Ash.	Potash.	Lime.	Magnesia.	Phosphoric Acid.
1.—BREWING.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1000 lbs. Barley, contain.........	855	15.2	22 23	4.48	0.58	1.92	7.71
15 " Hops "	13.2	....	1.00	0.345	0.167	0.056	0.168
Distribution of the Ingredients:							
Water..........................	....	....	1.23	0.852	0.039	0.045	0.234
Malt-Sprouts....................	33	1.38	2.43	0.749	0.069	0.066	0.653
Brewers' Grains............	260	8.74	13.08	0.580	1.474	1.134	3.631
Spent Hops....	9	....	0.54	0.023	0.160	0.055	0.062
Yeast..........................	30	2.94	2.27	0.643	0.097	0.185	1.349
Beer............................	....	2.14	3.65	1.998	....	0.484	0.939
2.—DISTILLERY.							
a. 1000 lbs. Potatoes, contain....	250	3.2	9.43	5.69	0.24	0.44	1.63
40 " Kiln-Malt............	37	0.56	1.06	0.184	0.040	0.088	0.388
20 " Yeast-Malt....	18.5	0.28	0.53	0.092	0 020	0.044	0.194
The Slump, contains............	125	4.04	11.02	5.966	0.300	0.572	2.212
(*b.*) Grain Spirits.							
800 lbs. Rye, contain............	684	14.08	14.32	4.501	0.376	1 648	6.710
200 " Kiln-Malt, contain.......	184	2.82	5.12	0.883	0 195	0.429	1.526
50 " Yeast-Malt, "	46	0.71	1.28	0 221	0.049	0.107	0.382
The Slump, "	443	17.61	20.72	5 605	0.620	2.184	8.618
3.—YEAST MANUFACTURE.							
700 lbs. bruised Rye, contain.....	599	12.32	12.53	3.941	0.329	1 444	5.876
300 " Barley-Malt, "	276	4.23	7.67	1 325	0.293	0.643	2.801
Distribution of the Ingredients:							
Yeast	45	4.60	3.41	1.273	0.192	0.367	2.672
Grains and Slump..........	325	11.95	16.79	3.993	0.430	1.720	6.005
4.—STARCH MANUFACTURE.							
1000 lbs. Potatoes, contain........	250	3.20	9.43	5.69	0.24	0.44	1.63
The remains in the Fibre........	75	0.60	0.54	0.086	0.266	0.042	0.133
" " " Water...... ..	45	2.60	8.89	5.604	...	0.398	1.497
5.—MILLING.							
1000 lbs. Wheat, contain..........	857	20.80	16.88	5.26	0.57	2.02	7.94
Distribution of the Ingredients:							
Flour (77.5 per cent).........	664	14.65	5.50	1.980	0.154	0.458	2.862
Mill-feed (6.5 ").........	58	1.64	1.80	0.648	0.050	0.148	0.936
Bran (16.0 ").........	135	4.51	9.60	2.672	0.396	1.394	4.102
6.—CHEESE-MAKING.							
1000 lbs. Milk, contain.......... ..	125	4.80	6.10	1.505	1.333	0.186	1.735
Distribution of the Ingredients:							
Cheese..........................	65	4.53	2.84	0.247	0.687	0.028	1.151
Whey...........................	60	0.27	3.26	1.258	0.646	0.158	0.584
7.—BEET-SUGAR MANUFACTURE.							
1000 lbs. Roots, contain..........	184	1.60	7.10	3.914	0.379	0.536	0.780
Distribution of the Ingredients:							
Tops and Tails (12 per cent of roots).........................	19	0.24	1.15	0.336	0.108	0.132	0.144
Pomace (15 per cent of roots).....	46	0.44	1.71	0.585	0.390	0.105	0.165
Skimmings (4 per cent of roots)..	24	0.60	1.20	0.380	8.640	0 240	0.384
Molasses (3 per cent of roots)....	25	0.32	2.47	1.741	0.141	0.009	0 015
Sugar and loss..................	85	....	0.57	0.872	....	0.040	0.072
8.—FLAX DRESSING.							
1000 lbs. Flax-Stalks, contain...	860	....	30.36	9.426	6.751	1.995	3.990
Distribution of the Ingredients:							
In the Water....................	215	....	25.15	9.175	4.100	1.850	3.400
Stems or Husks..................	460	....	4 03	0.171	2.052	0.096	0.474
Flax and Tow....................	155	....	1.22	0.054	0 648	0.054	0.126

INDEX.