AN ESSAY ON GUANO.

BY

I. E. TESCHEMACHER.
ESSAY ON GUANO;

DESCRIBING

ITS PROPERTIES

AND

THE BEST METHODS OF ITS APPLICATION IN
AGRICULTURE AND HORTICULTURE;

WITH

THE VALUE OF IMPORTATIONS FROM DIFFERENT
LOCALITIES;

FOUNDED ON ACTUAL ANALYSES,

AND ON PERSONAL EXPERIMENTS UPON NUMEROUS KINDS OF
TREES, VEGETABLES, FLOWERS, AND INSECTS,

IN THIS CLIMATE.

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PREFACE.

Manure is the staff, the chief dependence, of the farmer. The first action in the examination of a farm should be to observe the system of the farmer's management of his manure; from this alone a pretty good idea of the management of the rest of his affairs may be gathered. Without a proper understanding on this subject, it is impossible for him to excel in his cattle or his crops. Knowledge on the matter of manure is therefore of the greatest importance to him, and ignorance of it is what he ought to be most ashamed of.

A person may travel thirty or forty miles from Boston, in some directions, and not find one fiftieth part of the land on each side of the road well cultivated; while, in other parts, he would find acres from which is gathered annually from two to six hundred dollars of produce. This difference chiefly arises from application of the article of manure, the deficiency of which is probably the chief cause of the sterility in question.

It certainly appears rather singular that so much prejudice should be entertained against a manure like guano, backed as its efficacy has been by centuries of experience in South America, and by an immensely increasing consumption in England, where the utmost attention is of necessity paid to increase the produce of the land.

It is true, the greatest objections have been made by those who have never tried it. One is afraid the production of luxuriant crops every year will exhaust his land; as if it were desirable to have diminutive crops, and let the virtue remain in the soil. Another will have it that this country is too hot, and has not the
damp advantages of England; forgetting that South America is hotter still. A third, having applied an exorbitant quantity, against every instruction given, and thereby killed his crop, is unwilling to try again with a more economical distribution of it.

I have now experimented with this article for three years, and the number of my experiments have been nearly two hundred. With the exception of those on a few exotic plants of peculiar constitution, and also of those where I have pushed the application purposely to excess, in order to test its power, few of these experiments have failed. This pamphlet will therefore contain chiefly the results of my own experience; and, with those plants on which I have not tried the effect, I shall give my views of the best mode of applying this manure. And here I beg to observe that, having from my youth been practically acquainted with the operations and refinements of horticulture, and knowing well that experiments on this subject are liable to error when confided to unpractised hands, I have myself performed every part of nearly all the experiments, including the whole cultivation, which I give as my own, and have carefully watched and noted the various appearances they have offered at different periods of the applications.

During many months employed in chemical research on this subject, I have analyzed thirty or forty specimens from various localities. I am not at all surprised, therefore, at the very erroneous views taken of this manure by many professed chemists; so complex and varied is its constitution and the form of its ingredients; so numerous are the transformations they undergo. The analysis by exposure to heat gives only a true idea of the quantity of potash and soda, of the salts of lime, and magnesia; but of the most important ingredients, by this method, no correct notion can be formed. The conversion of the oxalates and the animal matter into their gaseous constituents, and the action thereof during this operation, entirely mask and confound the other substances; and, unless the drying, to ascertain the moisture, be very carefully conducted, part of the ammonia escapes, and is calculated as moisture. With all the efforts to obtain a true estimate of the ammonia, unless the
experiment be very attentively managed, the humic acid, &c., will still obstinately retain a portion. Many other difficult points remain, such as the detection of urea and uric acid, and the various combinations of the ingredients. The investigation of these is calculated to call forth all the resources and energy of the chemist; and, although the decision of many of them is not essential to the agriculturist, they are of high interest to the man of science. In my later investigations, I have received much valuable assistance from Richard Soule, Jr., formerly pupil of Dr. C. T. Jackson.

Following the example of those whom I consider the best analysts, I have endeavored, in the analyses made for agricultural purposes, not to make too many subdivisions, particularly when the quantity of an ingredient is small; they only perplex those whose object is practical utility.

The classification according to the agricultural importance is more easily understood, and bears a more true relation to the market value than any other, and, for all purposes of seller, buyer, and user, is therefore the best.

It has been thought that the supply of this article will soon be exhausted. That it will be exhausted I have but little doubt. If, however, the reports of travellers can be credited, — and there is no reason why they should not, — deposits are to be found of two hundred to three hundred feet in depth, extending many leagues along the coast of Peru. Such a mass will bear several years' consumption.

If a farmer should use guano for several successive years, he might store up his annual collection of manure, which, with proper covering and care, would retain its virtues just as guano does, and become a valuable capital for him to draw upon when the scarcity of guano rendered the price too high for economical use. And, at all events, the discussions to which its powers and action have given rise have rendered services to agriculture which can never be too highly valued.

In conclusion, I have been actuated, in my investigations of this manure, in my earnest endeavors to promote its introduction into
this country, and in this present attempt to disseminate information on the best methods of applying it, simply by the hope of doing some service in my generation; and it will be a source of much gratification to me if I can reflect that I have in any way promoted the progress of that most useful, that most honorable, employment of man—agriculture.
GUANO.

This substance, which has been used in South America as a manure for many centuries, retains there its Peruvian appellation of huano. The Spaniards, not having an aspirate $h$ in their language, replaced it by a $g$, the nearest sound to a guttural aspiration their alphabet possesses. Hence guano, pronounced by a Spaniard, is, in sound, more like the Peruvian huano than any thing else, and quite different from our guano, with a hard $g$. It is unquestionably the dung of sea-birds, which have for ages used the spots where it is deposited as places of resort during incubation.

The soil to which it is applied in South America, principally for the growth of maize, is of a sandy, sterile nature, containing but little organic mixture. Each crop has usually three applications of guano; the first, in small quantity, at the time of sowing the seed; the second, a larger application, when the plant is less than half grown; and the third, just previous to the commencement of ripening the seed. After each application, the land is irrigated—that is, watered. From this latter circumstance, it will be seen that the first application is of the nature of a steep in guano liquor, which, no doubt, accelerates the germination of the seed, while the dilution of the guano prevents the embryo from being injured by the action of the manure, and also causes the commencement of its decomposi-
tion, rendering it immediately available to the growth of the young plant. The volatile ammoniacal salts of the first application being exhausted, the second becomes necessary for the increased roots forming; and this, no doubt, enters largely into the substance of the plant, promoting in every way its growth, luxuriance, and production of seed. Of the benefit of the third application, I confess I am unable to judge; never having tried it, because I was unable to see beforehand the use of it. Nevertheless, I think that the common practice of a people who have used guano for centuries should not be slightly rejected without experiment, and it certainly shall be tried.

It would be a folly, at the present moment, to doubt the immense value of this powerful manure, when so many have witnessed the surprising effects it has produced; but it is certain that fraudulent adulterations, as well as improper applications of it, have produced failures in many cases. To those, however, who may yet be inclined to skepticism on the subject, it may be well to observe, that a single well-conducted and faithful application of guano, which has been crowned with success,—and there are hundreds on record, beyond all dispute,—must completely prove its beneficial effect; while a hundred failures can only prove error in its application, or fraud in the article. But it is fortunate for agriculture, that, within the last seven or eight years, science has taken up so vigorously the investigation of the laws of vegetable life, and, independent of any considerations on guano, has arrived at conclusions which enable it to prove and exhibit, in the clearest manner, the causes and reasons for this valuable action on plants, thus not only placing it beyond the region of doubt, but also affording valuable hints respecting the methods of the application to the various members of the vegetable kingdom. It is to these methods of application that I shall chiefly devote this pamphlet.
But I wish, in order to be better understood, first to enter into the discussion of the aptitude of its ingredients to the growth of vegetables, as well as of the different qualities of this manure brought from different localities, holding all knowledge on this interesting subject too valuable to be kept at home. It is, like the manure itself, the more beneficial the more it is spread abroad.

We are told truly, that the volatile parts of vegetation consist of

- Carbon, obtained by plants chiefly from the soil and atmosphere;
- Oxygen, obtained by plants chiefly from water,
- Hydrogen, carbonic acid, &c.;
- Nitrogen, obtained by plants chiefly from manure, and also from rain and snow;

besides which, they contain fixed or non-volatile inorganic ingredients, chiefly

- Silicium, in combination with oxygen, called silica, or sand;
- Lime, in combination with phosphoric and other acids;
- Potash and soda, in combination with acids;
- Magnesia, in combination with acids;

and various oxides of metals, the presence of which, however, is not very important, as they exist in exceedingly small quantity.

Now, without going any further into scientific discussions, which are not so interesting to the practical agriculturist at present as I trust they will be some years hence, it is enough to prove that all these ingredients, with the exception of the metallic oxides, exist in guano.
The ingredients of guano are as follows:

Ammonia, (formed of nitrogen and hydrogen,) combined with carbonic, oxalic, phosphoric, and other acids.

Lime, combined with phosphoric, oxalic, and other acids.

Potash and soda, combined with muriatic and sulphuric acids.

Magnesia, combined with phosphoric and other acids.

Animal organic matter, containing carbon, and also nitrogen.

According to the latest and most accurate analyses of plants, maize, or Indian corn, contains, in the ashes of its seeds,

Phosphoric acid, . . . . about 50 per cent.

Potash and soda, . . . . " 30 " "

Magnesia, . . . . . . " 17 " "

Lime, . . . . . . . " 1½ " "

Silica, . . . . . . . " 1 " "

The kind of corn is not named in this analysis.

Wheat ashes contain,

Phosphoric acid, . . . . 46 to 50 per cent.

Potash and soda, . . . . 34 to 37 " "

Magnesia, . . . . . . 9 to 16 " "

Lime, . . . . . . . 2 to 4 " "

Silica, . . . . . . . ½ to 1½ " "

with a little peroxide of iron and sulphuric acid.

The difference exhibited here in the quantities of the ingredients arises, probably, from the difference of soil in which the analyzed seeds were sown.

A most interesting question to be hereafter decided by
chemists and agriculturists is, To a preponderance in which of these ingredients does grain owe its most valuable and nutritious qualities, as well as flavor?

Rye ashes contain,

Phosphoric acid, . . . . 47 to 52 per cent.
Potash and soda, . . . . 30 " 37 " "
Magnesia, . . . . . . . . 10 " 10½ " "
Lime, . . . . . . . . . . 3 " 7 " "
Silica, . . . . . . . . . . ½ " 5/8 " "

with a little peroxide of iron and sulphuric acid.

Barley ashes contain,

Phosphoric acid, . . . . about 41 per cent.
Potash and soda, . . . . " 20½ " "
Magnesia, . . . . . . . . " 10 " "
Lime, . . . . . . . . . . " 3½ " "
Peroxide of iron, . . . . " 2 " "
Silica, . . . . . . . . . . " 22 " "

The quantity of silica is remarkable.

Buckwheat ashes contain,

Phosphoric acid, . . . . about 50 per cent.
Potash and soda, . . . . " 29 " "
Lime, . . . . . . . . . . " 7 " "
Magnesia, . . . . . . . . " 10½ " "
Sulphuric, . . . . . . . . " 2 " "

and a little peroxide of iron and silica.

Turnip-seed ashes contain,

Phosphoric acid, . . . . about 42 per cent.
Potash and soda, . . . . " 26½ " "
Lime, . . . . . . . . . . " 14½ " "
Magnesia, . . . . . . . . " 12 " "
Oxide of iron, . . . . . . " 3 " "
Silica, . . . . . . . . . . " 1½ " "


Silver fir ashes of seed contain,

- Phosphoric acid, . . . . about 40 per cent.
- Potash and soda, . . . . " 24 1/2 " "
- Lime, . . . . . . . . . . . . " 1 1/2 " "
- Magnesia, . . . . . . . . . . " 17 " "
- Sulphuric acid, . . . . " 12 " "

with some peroxide of iron and silica.

I have given this analysis, from the curious fact that the pollen of many of the fir tribe, clouds of which may be seen in the forests at the proper season, contains a large proportion of phosphate of lime. This must be extracted from the disintegrated rocks on which the pine often grows—a circumstance which led me to judge that, as guano contained much phosphate of lime, it would be well adapted to promote the luxuriant growth of this tree; and my experiments on young trees fully confirm this surmise.

Ashes of peas contain,

- Phosphoric acid, . . . . 31 to 34 per cent.
- Potash and soda, . . . . 39 " 47 " "
- Lime, . . . . . . . . . . . . 2 1/2 " 10? " "
- Magnesia, . . . . . . . . . . 6 1/2 " 12? " "
- Sulphuric acid, . . . . 3 1/2 " 5 " "
- Chlorine, or chlor. sodium, . 1 " 3 1/2 " "

with small quantities of silica and peroxide of iron.

These, it will be seen, are the fixed non-volatile ingredients of plants. All of them are found as constituents of guano, which contains, besides ammonia, or nitrogen, the only volatile ingredient required from manure; the other three—oxygen, hydrogen, and carbon—being obtained in sufficient abundance from soil, the atmosphere, and from water.

It would be useless to add further to this list; enough have been enumerated to give a general idea of what is neces-
sary for their growth, and also to show that all the ingredients of plants are found in guano. Putting guano into the soil, therefore, as a manure, is clearly restoring to the earth those substances which plants abstract from it, and which are absolutely necessary for their growth.

Now, the questions remain as to the quantity, cost, and mode of application. This last is of the utmost importance, as guano is a very concentrated, strong manure. Too much would be more injurious than none at all.

From what precedes, it is beyond dispute that guano contains the chief ingredients required for the growth of plants. The instances hereafter adduced will show that the combination and form of these ingredients are such as to promote not only its immediate action, but clearly to accelerate considerably the progress of vegetation. One of the numerous objections to this manure is, that, although it may answer well in the humid atmosphere of England, it cannot produce equal benefit in the hot, sandy soils of this country. In reply to this, it may be observed, that the sandy soils of South America are more hot than they are here; and, on the coast of Peru, where it is most used, it scarcely ever rains at all. The truth is, that it certainly requires moisture to decompose it, and enable it to enter into the juices of the plant; by no means, however, so much as is usually supposed; but, once absorbed by the roots and plants, it imparts that strength and solidity which enable them to resist both drought and cold.

As many of my experiments were made with guano from different localities, I will, at this point, give the most approved analyses; taking those which, having been made by Dr. Ure, my brother, and myself, for agricultural purposes, will be more simple and intelligible to agriculturists, as well as best adapted to illustrate the information I wish to convey.
ANALYSES OF GUANO.

In the discussion of these analyses, my observations will be chiefly confined to the agricultural value of the various ingredients, without at all entering into the scientific questions which must arise in the mind of every chemist who has studied this chemically-complex and intricate substance.

The chief ingredients, then, of guano, are,

Ammonia, in various forms and combinations;
Phosphate and oxalate of lime and magnesia;
Salts of potash and soda;
Animal organic matter;
Sand and moisture.

Let us consider their separate agricultural value.

1. Phosphate of Lime.—This is a valuable and indispensable ingredient in soils; but it is the same as bone manure, or bone dust, except that, in guano, it is in a finer powder, or state of division, than can be, in any way, artificially produced; and hence it acts powerfully and immediately. Many soils, particularly those with a large admixture of disintegrated granite,* contain naturally a considerable quantity of this substance; enough to supply the crops of many years of corn and other vegetables, in which a reference to the foregoing pages will show it to be a necessary portion. In such soils, it is therefore of little comparative virtue. In other soils, particularly those which are poor and sandy, it is a beneficial and necessary addition; but alone, it would be of little use, and, in quantity, even very injurious; being of a hot nature, as will

* Some very recent and interesting experiments seem to prove that phosphoric acid exists in many more rocks and minerals than has been hitherto supposed.
have been experienced by many who have used bone manure
injudiciously in their efforts to produce luxuriant vegetation,
and have burned up their plants. Phosphate of lime, in the
shape of crushed bones, can be obtained at a cheaper rate,
when required, than it can be purchased in guano. Notwith-
standing these remarks, in combination with the other ingre-
dients of guano, it becomes, in most soils, of considerable
advantage. It is insoluble in water.

2. Magnesia is already found, in most earths, in sufficient
quantity for the small demands made upon it by vegetation.

3. The Salt of Potash and Soda are valuable, but might
also be obtained cheaper from leys and other sources, to sup-
ply what is taken off by the crops.

4. The Sand is evidently of little value, except in clay soils.

5. The Oxalates are of little known general value as ma-
nure.

It must not, however, be imagined that these substances are
of no value in the guano; quite the contrary. I am, above,
only alluding to their separate values in any soil. For it
may be easily conceived that, if all the materials necessary
for the growth and perfection of a plant be presented to the
roots together, the growth may be more rapid, equal, and lux-
uriant, and the produce more certain and larger, than if the
roots had to search for each ingredient required, with the
uncertainty of finding them either within their reach or in a
state bringing them under the control of their powers; in
which state they exist in guano.

The feeding or absorption by the roots of plants, with their
faculties of abstracting, in a liquid form, substances insoluble
in water and in many of the chemist's liquids, is a subject
on which vegetable physiology has as yet shed but little true
light. The above is, therefore, only an idea suggested by
the visible operation of this manure, and by observations on its action at various periods of growth.

There remain, then, only the Animal Matter and the Ammonia to be considered, as the most important ingredients. The organic animal matter, as will be seen, is not in very large proportion, but what there is, is valuable; in the Peruvian and Bolivian guano, it is already combined with ammonia; and, in the others, much of it is resolvable into this substance.

6. Ammonia.—According to the best vegetable physiologists, nitrogen, or azote, the chief constituent of ammonia, exists in all parts of plants; and it is in the form of ammonia that it enters them. It seems to be the great agent in stimulating the increase and propagation of all the vessels in the plant. Hence, with an ample supply of this substance, combined with other necessary materials, Nature can push her development of root, stem, leaf, flower, seed-vessel, and seed, to its farthest extent. Ammonia, therefore, in some shape or combination, must be necessary in any manure destined to produce luxuriant growth; and it is the most valuable ingredient in guano, the mercantile worth of which is regulated principally by the quantity it contains of this substance.

In some of its combinations, however, it is more volatile—that is, evaporable in the atmosphere at common temperatures—than in others. That in the South American guano is less volatile than that in the Ichaboe and other African localities. This is owing partly to the Ichaboe being mixed with a portion of the remains of dead animals, partly from being the manure of the penguin as well as of the albatross tribe, and also partly from its being a more recent accumulation, and not having lain long enough to undergo the same decomposition as the South American. This last contains what Dr. Ure has named potential ammonia, which means simply
this substance in a more permanent form, and is, in this state, contained in the animal matter and in the uric acid, which latter is in extremely small quantity, if at all, in the Ichaboe guano. Humate of ammonia is also a very permanent form, and this likewise exists in guano.

Some from Saldanha Bay, which I have analyzed, seems to have undergone the same decomposition as the South American, although the rain which prevails there has washed out a large proportion of the ammoniacal salts; it also contains, like that, a portion of uric acid, but not near as much.

To choose guano, then, regard must first be had to the quantity of ammonia; and it is preferable when in the most permanent form: such is the Peruvian. The moisture is next to be considered; first, because it is water, and nothing else; and secondly, because moisture aids the decomposition and volatilization of the different ammoniacal ingredients, which is not desirable until the guano is in the soil. It should also be pretty free from foreign substances, such as dirt, sand, sticks, skin, stones, &c. The Peruvian and the true Bolivian are the best; after these, the first quality from Ichaboe, such as the cargo per Samos; then the second quality from Ichaboe, and that from Saldanha Bay. These are the only localities from whence cargoes have been hitherto introduced here.

The Chilian is quite inferior, and generally contains only eight to twelve per cent. ammoniacal salts. Numerous vessels from Europe are now searching in every probable place in the world for this manure. I trust and believe they will be successful. I purposely omit all reference to adulteration, as I think it has not yet been practised here to any extent; and the only caution I can give is, to request those who purchase to apply to men whose characters are above all suspicion of fraud and dishonesty. There are many such in the trade.
GUANO FROM SOUTH AMERICA.

The guano from Peru is the dung of birds of the albatross tribe, who have for ages covered the islands on this coast in countless thousands, during the time of their annual incubation, and have consequently formed immense deposits of this valuable manure. As it never rains on this part of the coast, the hot sun, with the dew, soon forms a crust over the newly-made annual deposit. Under this, a close species of decomposition and concentration takes place; and, the escape of ammoniacal gas being prevented, it becomes condensed into the other ingredients, and finally, after various probable, although not well-understood, transmutations, exists in its most permanent form, and in great quantity.

The guano from this part of the coast is therefore the most valuable of any for agricultural purposes, particularly for spreading broadcast, or where it is in any way exposed to the action of heat or atmosphere.

Under circumstances of exposure which would deprive the Ichaboe guano of a great portion of its ammonia, the Peruvian would retain the chief part. This must be borne in mind in its application.

The best analyses of Peruvian guano give, as ingredients,

33 to 40 per cent. of ammoniacal salts;
5 " 7 " " animal matter;
8 " 12 " " salts of potash and soda;
23 " 23 " " phosphate of lime and magnesia, and oxalate of lime;
10 " 13 " " water;
with a little sand.

This guano contains from seven to twelve per cent. of uric acid, and this, as before mentioned, forms an important part
of its value. The Bolivian guano is next in value to the Peruvian. It contains about three per cent. of uric acid. Analysis gives

about 36 per cent. of ammoniacal salts;
   " 5 " " " animal organic matter;
   " 16 " " " salts of potash and soda;
   " 28 " " " phosphate of lime and magnesia, and oxalate of lime;
   " 14 " " " water.

The Chilian guano is the most inferior of all those from South America, and contains no uric acid. Analysis gives

about 12 per cent. of ammoniacal salts;
   " 3 " " " animal matter;
   " 8 " " " salts of soda and potash;
   " 53 " " " phosphate of lime and magnesia, and oxalate of lime;
   " 22 " " " water;
   " 2 " " " sand.

AFRICAN GUANOES.

Of those from the coast of Africa, the best is unquestionably that first brought from Ichaboe—a deposit now unfortunately exhausted. But it does not contain uric acid. The best analyses give, as ingredients,

23 to 28 per cent. of ammoniacal salts;
   9 " 11 " " " animal organic matter;
   9 " 11 " " " salts of potash and soda;
   30 " 37 " " " phosphate of lime and magnesia, and oxalate of lime;
   18 " 25 " " " water.

The ammoniacal salts here are in a much more volatile
and soluble form than in the South American sorts, and therefore, in the application, it should be quickly covered up with soil; the ammonia then, as the guano decomposes by heat, moisture, &c., combines with the constituents of the soil, and takes a more permanent form, so that but little is lost.

The refuse African guano from Ichaboe, that from Pedestal Point, Algoa Bay, some from Angra de Pequena, Possession Island, &c., are much inferior to the above, and vary from ten to twenty per cent. of ammoniacal salts; the other ingredients increase in proportion to this deficiency. It is probable that a large proportion of the valuable salts have been washed out from these by rain. I have, however, analyzed a guano from Saldanha Bay, which, although by no means so rich in ammoniacal salts as that from Ichaboe, seems to have lain long enough to undergo the same decomposition as the South American guano, and to contain some ammonia in its most permanent form, with uric acid. Here, as before stated, the rain has also washed out much of the valuable ingredients, which is probably the reason why it contains so much less ammonia than that from South America, or rather from Peru. Vessels have gone to endeavor to find these ammoniacal salts washed out, and, if they succeed, will probably bring home valuable cargoes.

It will be seen, therefore, that guano varies as much as other manure, and that the reports of experiments on guano, without a perfect knowledge of the kind, and the exact method of application, convey no valuable information, give no rule which would be safe for the farmer to follow.

If that from Ichaboe be spread broadcast on the surface, and no rain follow immediately, the ammonia will evaporate, and the effect be altogether trifling; whereas the same quantity under the surface, where this ammonia could be absorbed
by the soil, and from this given off to the roots, would produce immense benefit; while that from Peru would comparatively lose little by the former method of spreading broadcast. For using in solutions in water, I rather prefer the best Ichaboo to the Peruvian, nearly the whole of the ammoniacal salts of the former being soluble; but, for using the whole substance, that from Peru is decidedly more permanent in its effects.

The best agricultural method of making an analysis of guano is, first to ascertain the quantity of moisture in one hundred parts, then to ascertain with exactness the quantity of ammonia they contain. The next operation is to see how much is soluble in water. This will give chiefly the salts of potash and soda. The ammoniacal salts, being known already, are burned off; the potash and soda remain behind. There are still left those portions insoluble in water. Such are the phosphate and oxalate of lime, and phosphate of magnesia, the sand, and the organic animal matter. These, although insoluble in water, are more or less decomposable by the action of the plant and the matters found in the soil; and, being in a state of extremely fine division, this action is quick and immediately serviceable to the plant. They are chemically discoverable by solution in acids, and precipitation by the usual tests.

Uric acid may be discovered and estimated, as stated by Dr. Ure, by treatment with a weak solution of borax, and precipitation by hydrochloric acid, and, for urea, by boiling the residue left after solution by boiling water, in very strong alcohol, in a thick flask.

The whole of these operations require extreme care and patience to give satisfactory results, and should always be done in duplicate.

I now proceed to give the result of my experiments.
APPLICATION OF GUANO IN CULTIVATION.

ZEA MAIS, OR INDIAN CORN,

THE VARIETY CALLED SWEET CORN.

Several hills were planted on a poor, sandy, sterile soil. First application, one teaspoonful South American guano, well mixed with the soil when sown. Second, when twelve to fifteen inches high, the earth was drawn away from around the hill, and about three teaspoonfuls strewed in the circle, which was immediately covered up again. This application was made at least five to six inches from the base of the stem, and the trench, by the hoe, from three to four inches in breadth, and one and a half to two inches deep. After this application, water was profusely given, as the weather was dry.

The corn from this experiment was exhibited in the rooms of the Massachusetts Horticultural Society. The produce of one seed was three chief stems, bearing eight perfect heads, and five suckers, each showing the silk, (the mass of pistils of the fertile heads,) and weighed, the roots being cut off, eight and a quarter pounds. The best plant from several adjacent hills without guano had only one head, and weighed, under the same circumstances, one pound and a quarter. I have since tried several applications with this plant, and find the best method as follows: —

Hollow out the hill, put in one teaspoonful and a half of guano, and mix it well with the soil. Spread even, then put on this about one or one and a half inch depth of light soil, on which sow the seed, and cover up. When the corn is about twelve inches high, or the time of first hoeing, begin with the hoe about four inches from the stems, and make a
trench the width of the hoe, about two or three inches deep. Spread in this trench about three or four teaspoonfuls guano, stir it in, and cover the trench as quickly as possible. If this last operation can be performed just before or during rain, the action will be quicker and more effectual. I have here named the quantity of guano. It is evident, however, that this must depend on quality, as previously stated. My experiments this year were made with best African guano, containing about twenty-six per cent. of ammonia; that which contains less of this substance should be used in greater quantity. The growth of corn under this treatment is so luxuriant, that, unless a much greater space than usual is allowed between the plants, to admit freely the action of the sun and air, fully to ripen the juices, the plant will be very subject to the smut. This is so certain a result, that I recommend the hills to be placed at nearly double the usual distance, and the seed thus sown also. This plant requiring considerable phosphate of lime for the perfection of the seed, it seems scarcely to admit of doubt that phosphate of lime, in a very fine and divided state, in the guano, being presented to the roots at the same time with the manure which promotes their growth, is easily absorbed by them, and must therefore be of great advantage, even in soils which already contain this substance. The same may be said of the magnesia, of which a reference to the preceding analyses will show that corn contains about seventeen per cent.

I have sown a piece of land, this year, with Indian corn, and manured with African guano, as stated; but, as it was an experiment, for the purpose of making into corn-stalk sugar, with a view of trying the virtue of guano in increasing the saccharine juice, I was obliged to cut off the heads as soon as they appeared. After the first early decapitation, another crop
of heads appeared, which were likewise cut off. I cannot, therefore, give the agricultural value of this experiment, but believe they would have averaged three heads to a stalk. The plants looked uncommonly luxuriant.

To exhibit the operation of the phosphates, in abundance, favoring the determination of the juices of the plant towards the formation of seed, I can state that, in many instances in the above experiment, three and four heads of corn grew from the axil of one leaf, from which usually only one springs; these in the guanoed corn were full, and would have come to perfection. In a parallel experiment on the same piece of land, where sugar-refuse was used instead of guano, the plants were comparatively diminutive and poor; but many had four, five, six, seven, and even eight, of these heads springing from one axil; they were, however, mere skeletons or embryoes. Sugar-refuse consists chiefly of phosphate of lime and charcoal, with scarcely any ammonia or magnesia; so that here, ammonia, and one of the ingredients of the seed, (magnesia,) were wanting. The plants were consequently diminutive in growth, and the seeds not perfect, but the tendency to form them in abundance seemed decided. Specimens of these growths were shown at the exhibition of the Massachusetts Horticultural Society this year.

There is little doubt that guano accelerates considerably the germination of the seed, as well as the growth of the plant. The piece of land above referred to was sown on the 22d of May, and was earlier than all the parcels of the same kind sown in the neighborhood with manure, the seeds of which were put into the ground the first week in May. This is of great importance, as lessening the danger by spring and autumnal frosts. Turnips I sowed, the evening of the 15th of August, on ground dressed with Saldanha Bay guano, broad-
cast and scuffled in with the spade; vegetated on the evening of the 18th, and, on the following morning, the surface was perfectly green with them. That sown on the adjoining piece two weeks previously, without guano, was just coming into second leaf. It is proper to add that I watered the guanoed piece copiously the day after sowing, as it was intended for an experiment on the power of the guano from that locality. Some farmers have thought best to mix guano with other substances, such as manure, muck, ashes, loam, &c., previous to spreading it on the land. On this point, my opinion is, that it is by far preferable to crush the lumps, and use guano by itself, or, if it must be mixed, only to use sand, or dry, sandy loam. The chief reason for this is, that stirring it about, in mixing, exposes the ammonia to be lost by evaporation in the air. This is, however, more the case with the African than the Peruvian, still even to a considerable extent with the latter. Muck is too moist and tenacious to enable it to be properly disseminated amongst the mass. Therefore, wherever any quantity is together, it would injure the sprouting seed; and moisture immediately causes guano to undergo the very decomposition which is required to promote vegetation; therefore this ought not to be produced until it is in the vicinity of the plant or seed. Ashes of wood contain the very alkalies which the chemist uses in his analyses to separate the ammonia. He also uses lime for this purpose. Therefore ashes, or any substance containing lime, must be an improper mixture; they would quickly drive off this the most valuable part of the guano.

The object of the farmer should be to place his guano in such a situation that, when its decomposition commences, the soil should absorb the products of this action, and that soil be in the immediate neighborhood of the roots of the
plant to be manured — they will speedily find it out of their own accord.

Manure, except when dry,— and then it is not very valuable,— is open to the same objection as muck; besides which, if guano alone will give an excellent crop, why throw away the manure?

Light, dry loam, and sand, are not objectionable. The latter is highly to be recommended on a clay soil, where the action of the guano is evidently much impeded.

GRASS AND GRASS LAND.

The application of this manure to grass land already laid down is, for many reasons, often attended with uncertain results. The best mode is, to spread broadcast about two hundred and fifty pounds per acre of the Peruvian guano as soon as the snow is off the ground. It would be very advantageous if, after it was spread on, some light loam could be put over it, in the manner of a top-dressing. I state the Peruvian guano is the best for this operation, as it contains what Dr. Ure calls potential ammonia, or ammonia in a more permanent form; whereas the ammonia from the Ichaboe guano evaporates more easily, and this valuable ingredient is therefore lost in the atmosphere when it is spread on the surface. I have already mentioned this previously, but purposely repeat it here. Most excellent crops have been obtained, where the grass is sown and laid down in the autumn, on light, sandy soils, by sowing the guano evenly broadcast, then harrowing twice, sowing the grass seed, and rolling. But in this, as in every case where guano should be applied broadcast, it seems to me that the most efficacious method would be to strew a quantity in the furrow made by
the plough; the soil raised of the next furrow will then lap over and cover it up. A very small quantity, say certainly not exceeding one hundred pounds to the acre, may then be sown broadcast on the surface, and harrowed in with the seed, in order, like a steep, to promote the luxuriance of the early growth of the plant. When the roots have attained a greater strength, they will then come in contact with that buried under the furrow, which, by the time it is wanted, will have become thoroughly decomposed in the soil, and be exactly fitted to the wants of the plant.

In several cases, where sods have been laid down for lawns or embankments round houses, the most surprising growth has been obtained by strewing the surface with guano previous to laying on the sod. The manure is then brought into contact with the roots, which—being strong and old, not tender and young, like the sprout and root of a seed—take immediate hold, and this effect is produced without injury.

I will here state that, on light lands, I consider three hundred pounds Peruvian guano to the acre quite sufficient; if Ichaboe, about one fourth more; and others according to the percentage of ammonia.

E. Baylies, Esq., of Taunton, sowed four hundred and sixty pounds of African guano (per ship Samos) per acre with grass seed, which yielded, this year, one ton per acre more than that without; and the appearance of the guanoed grass is now much more thick, luxuriant, and promising, for next year, than the other.

It is scarcely necessary to add that I consider wheat, barley, oats, rye, &c., as grasses, and these methods of application to be most rational, and give the most probable prospect of success. Every farmer, however, must reflect a little on the nature of his soil. I can, of course, only give general
directions, and exhibit the nature of the action of this manure. A man of any judgment, then, can hardly fail.

In the treatment of bush beans, a few pages hence, I state a fact respecting the flavor. I will here mention, relating to the same subject, that two cases are reported, in English papers, where the birds selected the fields of the guanoed wheat in preference to those manured, nearly eating up the first, and leaving the latter untouched; also, that I have the testimony of several friends, that their vegetables grown with guano were superior in flavor to any before tasted; and this entirely coincides with the whole of my own observations.

GRAPE VINES.

Here my individual experience is small, having only planted two vines, last autumn, manured with guano, which are growing vigorously. But many others have tried it on them with the greatest possible success, both as to growth of stem and fruit. This plant is a gross feeder, and will bear a great quantity of this manure without injury. Vines grown in pots will make a surprising growth if watered with a solution of guano; but, for the reasons given under the head of Indian corn, I think that the guano itself, containing the phosphate of lime, will give greater and better produce. The well-known success of others with this plant renders any evidence from me unnecessary. The best method of application is the same as for trees, which follows.

TREES.

The experiments with guano on trees which have come under my observation, including exotics number about one
hundred and fifty. The action has invariably been to produce large foliage, of a deep, healthy green, or with plants, usually covered with a white powder, called *glaucous*, to increase this appearance, and to shorten the joints or intervals from leaf to leaf. This last action, as respects fruit-trees, is of the utmost importance; every one being aware that long-drawn, long-jointed shoots are the least valuable or productive, and that the fruit-bearing spurs on trees are but branches with shortened joints. Hence the production of short-jointed, stocky branches is the production of so much fruitful wood; and if, by proper pruning, the sun and air are admitted so as to ripen the wood, a plentiful crop must be the result.

The best mode of application to fruit-trees seems to be, first, to consider where are the young feeding roots,—that is, at what distance from the stem, and what depth in the ground,—then to place the guano as near them and as much around them as possible, without being in absolute contact.

For instance, round an apple-tree of ten years’ standing, dig a trench, one or one and a half foot deep, at about the same distance from the stem that the branches extend; let this trench be about one foot wide; then put at the bottom one and a half inch depth of guano, dig it well in, and incorporate it with the soil; then cover up carefully, and press the earth down. The effect of this application will unquestionably be felt for several years.

I am rather inclined to attribute this shortening of the joints chiefly to the action of the soluble portions of the guano; as the pelargonium, the orange, and many other plants which exhibited this appearance, had only been watered with its solution. But, in all applications to fruit-trees, I recommend the guano itself, as the insoluble portion contains the chief materials of the seed, to protect and cover which fruit
is formed. Where young trees are to be manured, a little guano, dug in at the surface around the tree, as well as in a trench, will be advantageous.

The use of guano for trees probably combines another advantage of inestimable value; this is, the destruction of the insect tribe which are buried in the earth, and emerge from thence with the warmth of spring. The coverings of these insects, when they first come out of the ground, are not hardened; and, in this tender state, the contact with a moderately strong solution destroys them. I have tried experiments on about eight or ten various caterpillars, and some other insects, and have invariably found a solution of guano kill them quickly, except when in an advanced state; then it took a longer time and a stronger solution. Salt and oil-soap are both apt to be injurious to vegetation; but, by strewing guano around the trees, and turning it in a little depth, the plant will be benefited, and the insects at the same time destroyed. My experiments on this subject, although perfectly convincing and satisfactory to myself, have, for want of time, not been conducted with that care and precision which should authorize me to lay them before the public with requisite confidence. My last experiment was with the destructive grub *melolontha*, so well known to subsist on the roots of grass, of which a friend kindly sent me a box. Six of these white grubs were placed in a saucer half full of water, in which a teaspoonful of African guano had been put and well stirred. They immediately began to feel uneasy, and, in about two hours, the whole six were dead.

Several friends, who have tried guano this year on their pear-trees, have reported to me the result to be greater crops, and of a much larger size, than they ever had previously. The improvement of the flavor of fruit is an experiment yet
to be tried on an extensive scale, previous to a final determination of this important question.

PEAS.

The kinds on which I experimented were Prince Albert, Shilling's early grotto, (a dwarf pea,) blue imperial, and marrowfat.

The method I adopted with all was to draw a deep trench with a hoe, to strew guano in the trench, mix it up with the soil, over this put about one inch and a half of earth, then sow the seed, and cover up. In this way, I calculated that the young sprouts of the seed, both root and embryo, could not be injured by coming into immediate contact with the guano, and that, when the roots were strong enough to bear it, they would find the guano in that state of decomposition best suited for them. The quantity used was about three pints of Ichaboe guano to a quart of seed, sown, however, much thicker than is customary here. It will be observed that, in this case, the natural moisture of the soil, at the depth at which the guano was placed, was sufficient to bring it to a proper state of solution, and rendered the necessity of immediate rain not of so much consequence. When rain did come, it was beautiful to see the luxuriance resulting, and I felt persuaded that none of the virtue of the guano had escaped at the surface. The produce of the first three kinds of pea was five full pecks to the quart of seed, besides a full quart of seed gathered for next year. From the marrowfats I obtained only four pecks and a half, and no seed. The growth of all was extremely luxuriant. The marrowfats were six and a half feet high, the stems from one to one and a quarter inch in circumference. On the blue imperials, almost
every flower bore fruit. On a stem thirteen inches high there were twenty-two pods. This was not at all uncommon, and such was the specimen I exhibited this year at the room of the Massachusetts Horticultural Society. Many pods of the crop contained nine or ten peas; these would be valuable for seed. I also exhibited very luxuriant specimens of Shilling's early grotto in the same hall. The joints, or distance from leaf to leaf, was very much shortened—an effect of guano which has been remarked on in its application to fruit-trees.

I have previously observed that rain was not so absolutely necessary as is supposed. It will be seen that, in this experiment with the pea, the guano was placed at such a depth that the natural moisture of the earth decomposed it, and rendered it fit for the plant. It is seldom that drought penetrates so deep as this into the soil; therefore, if the application be made judiciously, dependent on the nature of the soil, and if its capacity for retaining moisture be considered, the want of rain is not so fatal an objection to the use of guano as might be thought. Thus, for instance, in the lightest soils, plough and bury guano a little deeper than in others more heavy; the guano itself retains moisture, and absorbs it naturally.

CHINA BUSH BEAN.

A row was sown on each side of my garden-walk. One was partially shaded from the hot sun. This was tried without guano. To the other, fully exposed to the sun, guano was applied in the same way as with the peas. The guanoed row bore nearly twice as many beans as the other; and, while that was turning yellow with partial exposure to the heat of the sun, this, exposed to its full influence, remained green
and unscorched. Between the produce of these two rows a marked difference in flavor was observed by myself and family, although the latter were not aware of the difference in their cultivation. I need scarcely add, that those with guano were of the most agreeable taste.

In this experiment, particularly, the stability given to the plant, and its power to resist the heat of the sun, compared with the other, are remarkable. This was evidently also the case with the peas. There were, with these, however, no unguanoed rows to institute a parallel, but only those in neighboring gardens. A friend of mine sowed grass, last autumn, in the sandy soil near Taunton, with a full quantity of manure, and an adjoining acre, as an experiment, with four hundred pounds of Ichaboc guano. The guanoed acre grew stronger, and retained its full verdure the whole winter; the manured piece, on the contrary, became, as usual, brown by the action of the frost.

From these and several other experiments reported to me, it seems clear that this manure gives a stability and strength to vegetation which enable it better to resist both cold and heat, as well as drought, than when the usual manure is employed.

MELONS.

The two kinds tried were the green-fleshed cantaloupe, and some seeds which I received as the sweet melon of Ispahan. They were both steeped in guano water, and raised in a parlor. At the proper season, they were planted out on poor soil, with the addition of three teaspoonfuls of African guano to the hill, and afterwards occasionally watered with a weak solution. On two plants of the Ispahan I had five fruit, two of a good size. They are all now (September
16th) nearly ripe, being quite yellow. On the one plant of the cantaloupe there was only one fruit, and that not very large. It is naturally a shy bearer, and was unfortunately placed by accident in a very shady part of the garden. I do not think the fruit will ripen. The roots of melons, squashes, cucumbers, and most of the cucurbitaceous tribe, spread about at very little depth from the surface of the ground—a circumstance which must be taken into consideration in the application of guano; and, generally speaking, a knowledge of the natural growth of the roots is necessary to decide on the best method of using this manure. This is so evident, that nothing further need be said on the subject.

POTATOES.

I have not made any experiment, but must refer, in this case, to numerous experiments of others, which are detailed in various agricultural publications. Nearly all the comparative experiments I have read on this tuber are certainly in favor of the guano. By attending to the observations respecting the roots, in various pages of this essay, no difficulty can be experienced in the method of application.

E. Baylies, Esq., of Taunton, has kindly furnished me with the following result of his experiment on potatoes:—

Soil, very sandy and light; quantity, eight hundred pounds African (per ship Samos) to the acre; cost, twenty dollars. Same soil, with twenty-two loads fine compost manure, cost twenty-two dollars. Yield, as eleven to nine, or twenty-two per cent. in favor of guano, the potatoes with which were larger than the others.
CELERY.

I was indebted to my friends for young plants of this vegetable; consequently, my experiments did not commence with the seed, and were therefore hardly so early as they should have been. After digging two trenches, in one I strewed a good layer of Ichaboe guano, and dug it in the bottom of the trench; then, watering well, I put on two inches of soil, and planted the celery. In the other, I planted without any addition, for the purpose of experimenting with guano water. This latter I watered, three times a week, with a solution of one pound African to fifteen gallons of water. The last-mentioned plants grew more rapidly than the others, and are now more advanced than those with guano; but the others are rapidly gaining on them. This experiment will be a good test of the question of flavor.

TURNIPS.

I have already mentioned two experiments with this vegetable. The guanoed plants are now as large and fine as those without guano, and are fast getting beyond them. I set off a portion of the unguanoed piece, and gave it, once a week for three weeks, a copious application of moderately strong guano solution. The plants on this portion are now twice as large as those which have not had any. It is perfectly beautiful to see the luxuriance of all these guanoed vegetables compared with the others.

STRAWBERRIES.

A bed of Hovey's seedling was planted in November, 1844, just previous to the ground being closed by frost. As early
in the spring as the state of the soil would permit, I drew a
trench, with a hoe, between the rows of plants, about two
inches deep, put in guano, stirred up, and covered it over,
thinking that the roots would naturally find the guano. From
this bed I gathered a plentiful crop of fine fruit, which I
believe would not have occurred without the guano, as the
soil was in a miserable, meagre state.

I am now trying two experiments on the same poor soil;
one, a bed of strawberries with guano dug into the soil, at
the rate of four hundred pounds Ichaboe to the acre; another
without guano, but watered once a week with guano water.
This watering I propose to continue in the spring, and shall
then see which will produce the best crop, with the best
flavor. At present, the watered plants are much more thrifty,
and larger, than the others, and are throwing out numerous
runners, which, of course, are removed.

CABBAGES.

My experiments with this vegetable have hardly been suf-
ficiently numerous to be satisfactory. I have only tried the
late savoys. About three weeks after planting out, I began
to water, twice a week, with a solution of guano. The plants
are now in fine luxuriance, exhibiting large, deep, green glau-
cous foliage; but I fear that, owing to want of time, they
were hardly planted early enough to form large heads previ-
ous to the arrival of frost.

Five of these plants I transplanted to another part, for the
purpose of trying the Saldanha Bay guano, of which I gave
them each about a teaspoonful when planted, and afterwards
watered with a solution. They are, at least, as luxuriant as
the others.
CAULIFLOWERS.

Two experiments, one with guano, the other with a solution. The first are fine strong plants, particularly one to which I gave a larger share than the others; it is heading finely. But those with the solution are much larger and finer. I have been accustomed to observe the cultivation of this vegetable, and never saw such a luxuriant growth. They are now (September 15th) beginning to show flower; and, if the season is favorable, I expect the heads will be very fine. The plants are at least four times larger than those on the same piece without guano, or any manure at all, planted on the same day, from the same seed-bed. This will give some idea of the poor, exhausted state of the land on which all my experiments have been tried.

The whole of my cauliflower plants were dreadfully infested with the gray aphis, or louse, which has this season been very common. As this was an experiment, I used every possible means to destroy them — Scotch snuff, oil-soap, and guano water. The insects were so numerous, and so well protected by their gray powder, and the curl of the leaf, that the utmost force of the syringe was almost unavailing. Scotch snuff killed them, but they soon reappeared. Both oil-soap and guano water were pretty effectual; of the two, I prefer the latter. Although I took great pains to eradicate them, they unquestionably delayed the growth of the plants a fortnight, which, I fear, may prevent their heading sufficiently for exhibition previous to frost. The plants are now two feet and three quarters in height, and two feet and a half in diameter.

There are many other vegetables on which I should like to see experiments. For instance, on rhubarb, guano would un-
questionably increase the size of the salable part, and probably much improve the flavor. On asparagus, I am sure the effect of forking it in as early in the spring as possible would be extremely beneficial; but it should be used without any other addition.

On *camellias*, *pelargoniums*, *cactæ*, *amaryllis*, *hippeastrum*, and many bulbous-rooted plants,—*orange-trees*, *passifloras*, *acacias*, and a great number of other exotic plants,—I have made various experiments, the detail of which would hardly interest the general readers of this pamphlet. The result, however, is an opinion that, where size and beauty of flowers are required, a solution of guano in water is preferable to the guano itself; but, wherever fruit is desirable, the guano, applied with proper discretion, is best. Another important observation on this subject is, that guano, or its solution, should never be applied except at that period of the season when the growth of wood is proper and natural. For instance, after the camellia has formed its full-sized buds, if guano, or the solution, be applied liberally, the plant will immediately begin to form new shoots, the buds will be left behind, and the flowers will open with diminished beauty. This, at least, is my experience.

This manure, owing chiefly to its ammonia, is of so stimulating a nature, that it will start vegetation at any period when the temperature of the surrounding atmosphere will permit it to proceed, and will, therefore, become of great importance in forcing-houses.

On roses, the beneficial effect is already well known. If tea-roses are cut down when the bloom is over, repotted in fresh earth, and well watered, twice or thrice a week, with guano water, they will immediately throw out luxuriant shoots, and be covered with their fragrant blossoms. I have two
tea-roses in pots, which are now, for the fourth time, in bloom since February.

I exhibited, this year, at the room of the Massachusetts Horticultural Society, *echinocactus ottonis*, three years' old from the offset, with three flowers expanded, and eight buds, not one of which failed to produce large, well-formed flowers; also *echinocactus eyriesii*, in blossom, being an offset three years old. The appearance of these plants was of the most healthy kind. But, with all succulent plants, in order to induce blossom, the luxuriant shoots must be well ripened by exposure to sun and air. I placed an *epiphyllum* in the annual exhibition of the Massachusetts Horticultural Society this year, which I grafted June 17, 1844; grown chiefly in moss, with very little soil, and watered profusely with guano water. It had thirteen shoots, many of extraordinary size and vigor. The *cactus* tribe will bear a larger quantity and stronger solution of guano, without injury, than most other plants; but then the enormous shoots must be well ripened, or they will not produce much blossom. This, of course, is the case with all fruit-trees. A large, soft, spongy growth of unripened wood, such as I have seen exhibited, is of no value whatever.

**GENERAL REMARKS.**

The experiments I have detailed in this essay were undertaken solely to gratify my own curiosity, and without any idea of being published, except, perhaps, a few results in some of the agricultural periodicals of the day. They are, therefore, neither so scientifically nor so practically complete as they
would have been, had I originally contemplated this publication.

During their progress, however, I have been so delighted with the unfailing and extraordinary luxuriance of growth and produce, on a miserable spot of land, induced by the use of this manure, and so struck with the numerous instances which have come to my knowledge of erroneous applications of it, that, incomplete as my experiments are, I have thought an essay like the present, circulated in the cheapest possible form, containing the result of my experience as it is, could not fail to convey some valuable information to the agricultural and the horticultural public.

My other numerous avocations prevent me from polishing the style, or attending minutely to the arrangement. I have stated it is intended merely to convey information; and as such alone I trust it will be regarded.

The quantity to be used per acre must depend both on the quality of the guano as respects its ammonia, and on the nature of the soil. On a stiff clay, guano would be of little value, except on the surface, or an inch or two deep, unless it were considerably lightened by the addition of sand, or well broken up by exposure, in ridges, to frost, as every clay soil should be. A light, porous, sandy soil would require three hundred pounds Peruvian, or four hundred pounds best Ichaboe; and for this soil I think the Peruvian best adapted, as it retains the ammonia longer, and, being less soluble in water than the Ichaboe, its qualities are not so soon washed out.

A more retentive, loamy soil would be as well affected by the Ichaboe, if buried at a proper depth to meet the demands of the roots, and to be out of the reach of a hot atmosphere.
A wet soil should be properly drained; but, if this be not possible, let the guano be placed a few inches below the surface, so that the roots may come into contact with the solution, and afterwards find the more solid ingredients of the guano.

In a soil already much enriched with manure, and at the same time abounding in phosphate of lime, I have found the guano to produce less visible effects than on a poor, sandy soil.

Most excellent effects have been produced by steeping seeds in guano water of moderate strength for eight to twelve hours, dependent on the kind of seeds, and then planting with one to three inches soil between the seed and the guano buried. The steep encourages the growth of the young plant, whose roots, in a more advanced stage, find the guano, which continues the stimulus.

It is very difficult to give precise directions for every seed and every soil. My object, in this pamphlet, is to make all as well acquainted with the nature of this manure, its action, and its effects, as myself. They can then use their own judgments, which, probably, in many cases, will be better than mine.

I have said, above, that the quantity proper to be used depended on the quality, and that the chief test of this quality was the quantity of the ammonia, and, in some cases, its permanence. Thus, if two hundred and fifty pounds of Peruvian guano, containing thirty-three per cent. of ammonia, are sufficient for an acre, then four hundred and fifty or five hundred pounds of guano, containing sixteen or seventeen per cent., would be an equivalent, yet with this difference—that the latter would leave nearly double the quantity of phosphates of lime, magnesia, &c., in the soil, after the crops
are taken off; and this, we shall see in the following pages, is not a small advantage. Yet, to obtain a luxuriant growth, a certain quantity of ammonia is requisite, and must be given by the additional weight of the latter quality. In using solutions, nearly the same remarks apply. The phosphate and oxalate of lime, &c., are insoluble in water; the soda, potash, and ammoniacal salts, are alone dissolved. I usually put one, one and a half, or two, teaspoonfuls of guano, according to quality, in a quart bottle, shake up, and, when settled, use; then refill and use two or three times, previous to putting in fresh guano. Or, in the large way, from fifteen to twenty gallons of water to one pound; this I mix in a barrel, stir up, and leave it to settle, taking care, however, to put a cover on, that ammonia may not escape more than can be helped. I have always found it advantageous, with plants in pots, — with celery, cabbages, &c., — to stir the earth frequently on the surface, the fine particles of earth and guano being apt to form a cake around the plants, and prevent the solution from reaching the roots until a portion of its virtue has evaporated.

Besides a considerable saving in labor in putting on, the farmer will find a great economy in the labor necessary to keep his land free from weeds; for common manure is well known to be a most fertile source of these pests of agriculture, arising from the seeds which are thickly scattered through it; whereas in guano there are none. So that those who are active in destroying weeds before they come to a mature state may, by the help of guano, be enabled to keep their land clear of so unsightly and unproductive a crop.

One of the most serious objections I have heard against guano is, that it will exhaust the soil. I have already discussed this question in one of the respectable agricultural
periodicals of the day, but will repeat my arguments here, and add a few more, all tending to show that this idea is erroneous. Let us take a poor, sandy soil, which naturally produces no crop worth taking off: with the help of guano, we obtain, year after year, luxuriant produce. The same may be done with land exhausted by cropping without manure. Here, certainly, the doctrine of exhaustion cannot apply; and yet these are the soils on which the virtues of guano are most eminent. Let us see how it will apply to better lands, where, according to some, the danger of exhaustion exists. The manure for one acre of land now costs about twenty dollars. Guano, for the same piece, would cost one third of this amount, if the difference of labor in putting on be included, and no weeds are sown. Therefore the land can be manured, for three years, with guano, at the same expense as one year with barn-yard manure. The first year, the produce with guano will exceed the other, in quantity and quality, from ten to twenty per cent. The second year, the difference will be greater, as the barn-yard manure will be partially exhausted. The third year, the difference in favor of guano will be greater still, very little virtue being left in the other manure. What will be the relative state of the soils at the end of the three years' operation? The great stimulant in both, ammonia, will be nearly exhausted; the surplus quantity of potash and soda, left in the earth after the three crops, may probably be equal in both; but of the great ingredients of seed, phosphate of lime and magnesia, more than four times as much has been put on in the guano as in the other manure, and, as I have before stated, in the best possible state of division for the use of the plants. To call these phosphates into action, little more is required than a sufficient supply of ammonia; and, if this be given the fourth year by
barn-yard manure, a most luxuriant crop must result, and, for some years, the benefit of these phosphates will be felt. It seems to me that this clearly disposes of the question of exhaustion, and that three years' use of guano will leave the land in a much better condition for the reception of barn-yard manure than ever it was before. This must be strikingly the case in a soil where the natural supply of phosphates has been much diminished by constant cropping with corn. The reports from Scotland are, that the beneficial effects of one application of guano were very evident the third year; and I will here introduce the following sketch from the Gardener's Chronicle, July 26, 1845.

"Penrith, Cornwall, (England.) Farmer's Club.

"Mr. Silvester cut, last year, four tons per acre grass, on land dressed with guano, and this year, without any additional supply, had more grass than he ever grew before in any one season.

"Mr. Tyacke had sown part of a field with Peruvian guano, at the rate of two hundred weight (two hundred and twenty-four pounds) per acre, and found the wheat much superior; it was sown in with the seed. He manured a field with four hundred and forty-eight pounds per acre, and thought the quality of this better.

"Mr. N. Permewan applied it to ten acres wheat, at two hundred and twenty-four pounds per acre; the result was astonishing. He had also applied three hundred and thirty-six pounds per acre to twenty acres grass; the effect produced was most beneficial. He had also tried it on part of a field of thirteen acres turnips. Part was manured with farm-yard dung and earth, (mixed,) at the rate of ninety to one hundred loads per acre; but a space of seven acres, in
the centre, was manured with guano, at two hundred and twenty-four pounds per acre. The turnips were as good on the guanoed piece as on the other. After the turnips, he sowed the whole with wheat, and no one could tell which gave the best crop.

"Mr. Tyacke found the poorer the soil the better it worked. He sowed the guano with the seed, (wheat.) Last year he sowed eight acres, as follows:—

“One third with bone-dust, at two quarters and a half per acre—crop fair; one third with guano, two hundred and twenty-four pounds per acre—crop one third larger; one third with farm-yard dung, forty loads per acre—crop the worst. This year he sowed the same piece with barley, without any addition. At first, the piece with farm-yard manure looked the best; then that with bone manure; now that with guano was better than either."

In this last experiment, the probability, from the action, is, that the phosphates had become exhausted by previous cropping, and that, therefore, both the bone-dust and the guano produced better crops than the manure, in which the phosphates are less abundant.

Science now teaches, and teaches truly, that the atmosphere yields its portion of the growth of plants, as well as the soil. Hence, the larger the vegetable surfaces we can present to the atmosphere, in the shape of luxuriant stem and foliage,—and this is effected by ammonia,—the more we shall absorb from it, and the larger will be the crops; provided, however, that we do not continue to stimulate the growth of these surfaces longer than the season will permit the juices of them to become ripened by the action of sun-
light and air; and, for this purpose, sufficient distance must be allowed, between luxuriant plants, for a full circulation of the atmosphere. On the necessity of this ripening I have already dwelt long enough, and will therefore merely add, that from errors of this nature will be found to arise most of the favorable circumstances engendering smut, rust, and all those unsightly fungous growths which destroy the beauty and produce of vegetation. These diseases are generally caused by an overabundance of the unripened juices of plants, which offer favorable circumstances for the vegetation of the seeds (spores) of fungi, which, at certain seasons, are always floating in the atmosphere and being deposited on the soil, and which attach themselves wherever there is a chance of their growing. This disease is seldom found in dry spots, where the air and sunlight circulate freely, and ripen the juices, unless these juices are produced in such quantity, and the season is so wet, that this ripening process is impossible.

With respect to the action of guano in the southern sections of the United States, I have no information. It is, however, well known that it has been very beneficial in the cultivation of the sugar-cane in the British West Indies; and I think tobacco planters would find it of extraordinary efficacy.

The most singular and apparently mysterious case of the action of guano occurred on the farm of John L. Tucker, Esq., of the Tremont House. He had a piece of grass land which was overrun with sorrel. Thinking guano might destroy it, he mixed a quantity with dry loam, and spread it, this spring, over the field as a top-dressing. The result was a most luxuriant crop of grass, without a particle of sorrel. This can be well understood; for a farmer has only to manure highly, and the grass will soon choke off the sorrel, which only grows on poor soils. Having emptied his bags
of guano, after beating them well, they were laid down on a piece of pine-barren, which, as is well known, is merely a dry crust of moss and lichens, with here and there a few diminutive strings of poor sorrel creeping through. On removing these bags early in September, what was Mr. Tucker's astonishment at finding a thick, tangled mass of the most luxuriant sorrel, such as is in great request with him for the elegant French cookery of his house! I have now before me a single turf, which he kindly sent me, two and a half feet long, one foot wide, one half of which is pine-barren, the other half this beautiful sorrel. This was a sore puzzle, that, in one case, as he thought, the guano should kill the sorrel, and in the other make it grow luxuriantly. I have already accounted for the first action of guano; and the second is equally simple. On the pine-barren there was no grass, or any other vegetation, except the thick matting of moss and lichens, and the small strings of sorrel. Moss and lichens, when decomposed, form a good soil, and this decomposition is quickly effected by the salts in guano. These are well-known facts. Here, then, is a bed of soil ready for vegetation. Sorrel is a plant containing a large quantity of oxalic acid; and two of the ingredients in guano are oxalate of ammonia and oxalate of lime. We have then a bed of soil, ammonia, lime, potash, soda, and oxalic acid,—every thing requisite to make sorrel grow, and no grass to choke it off by rank luxuriance. These circumstances are surely sufficient to account for the growth in question, and to reconcile this seeming contradiction.

Since many of the foregoing remarks were written, I have received so much unsought, yet concurrent testimony respecting the improved flavor of many vegetables, but particularly
of sweet corn, grown with guano, that I can no longer consider it possible for my imagination or my bias to have led my judgment astray on this point. If true to the extent which I suspect, the importance of the subject, both as regards fruit as well as vegetables, is great indeed, and well merits careful and extensive parallel experiments. These my other duties will not permit me to pursue, but I trust many will be found both able and willing to undertake them. My opinion, as I have before stated, is, that the presentation to the roots, in abundance and together, of all the ingredients necessary for the most luxuriant growth of every part of the plant, including the seed, as is the case with guano, must also produce the luxuriance of the coverings, or the receptacles of the seed; these, in a horticultural sense, mean the fruit. This has been verified, in an instance related to me this year, with the seckel pear, which had always previously borne fruit of a very small size. This year guano was liberally applied to the tree; the fruit has been uncommonly abundant, and of an extraordinary size. Of the flavor I cannot speak, not having tasted it. Mr. Tucker has also found the same result with the Baldwin apple, as compared with adjoining trees not guanoed.

Our evidences as to the ingredients of the guano entering the juices and seeds of the plants, though not numerous, are simple and incontrovertible, and therefore of great weight. Mr. A. A. Hayes, of Roxbury, found about thirty per cent. more phosphoric acid in the guanoed than in unguanoed sweet corn, calculated from the quantities of glacial phosphoric acid obtained by the incineration of six hundred grains of each; and, had this able chemist also searched for the magnesia, he would, in my opinion, have found, at least,
an equal increase in that ingredient. The following instance will support this idea.

In the *Annales de Chimie*, there is an account of some experiments on *fuchsia fulgens*, with guano, by Dr. A. Vogel. He found that the plants with guano were in full bloom, while those without were only in bud. The two plants were burned to ashes.

100 parts, by weight, of the guanoed plant, gave 6.2 ashes.

" " " " " not guanoed " " 7.3 "

These ashes consisted chiefly of carbonated alkalies, muriate of soda, sulphate of potash, and some phosphates.

The difference of the phosphates in the two is only 0.2 per cent. The guanoed ashes contained 25 per cent. carbonate lime, and 27.1 carbonate magnesia; the ashes not guanoed contained 40.2 per cent. carbonate lime, and 23.7 carbonate magnesia; showing that there was 3.4 more magnesia in the guanoed ashes than in those not guanoed.

Although this seems decisive with regard to magnesia, the experiment proves nothing respecting the seed, which may be one of those not intended for animal nutrition, and, consequently, in which phosphate of lime may not be requisite. In making experiments with the ashes of the plants themselves, and not with the ashes of the seed alone, it may be considered, however, that the necessary ingredients pass through the plant in their way to the seed.

The connection of these observations with flavor is, simply, that the phosphates certainly, and probably magnesia also, being necessary to the formation of flesh and blood, it is no great stretch of the imagination to suppose Providence to have ordered that these ingredients, in abundance, should produce a more grateful flavor than in smaller quantity.

The practical application of these facts is, that, in the
cultivation of fruits, and all esculent vegetables, particularly those designed for animal nutrition, the guano in a solid state should be used, and not a mere solution; for the phosphates of lime and magnesia are insoluble in water, but are taken up by the roots, and are probably the cause of the improvement of the flavor; whereas, for ornamental flowers, where seed is not required, and a fine growth of foliage is desirable, the solution is preferable.

It is very often the case that large fruits have not the fine flavor they have when grown small; in other words, that flavor is often sacrificed to size. If this could be avoided by the use of guano, and large size accompany improved flavor, it would be of great importance to the fruit and vegetable grower and eater.
Compiled from Wilmer and Smith's European Times, July 26, 1845.

**Import, Stock, and Consumption, of Guano in Great Britain since its first Introduction, in 1841.**

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From 1st July, 1844, \(\frac{1}{2}\) Peruvian, 27,600 to 1st July, 1845, \(\frac{1}{2}\) African, 245,510

Supply total, 291,650

Consumption, 136,100

Stock, 1st July, 1845, 135,550

Consumption in Great Britain, from 1st July, 1844, to 1st July, 1845, 135,550 tons.

Value, at £6½ average per ton, £881,075, or ... $4,291,169

And the stock on hand, 140,000 tons, ... $4,368,900

Aggregate expended for one species of manure, ... $8,659,169