

THURSDAY, OCTOBER 5, 1899.

## BERTHELOT'S AGRICULTURAL CHEMISTRY.

*Chimie végétale et agricole.* Par M. Berthelot. Four volumes. Pp. xvi + 511, vi + 441, vi + 517, vi + 528. (Paris: Masson, 1899.)

THE ancient Château de Meudon, Seine-et-Oise, which was left in ruins at the end of the war of 1870, was thirteen years later converted into an agricultural experiment station by the French Government, and permanently attached to the Professorship of Organic Chemistry in the Collège de France. In the four bulky volumes now before us, the professor, M. Berthelot, has brought together an account of the various investigations carried out at the station between 1883 and 1899, under his direction, with the assistance in many cases of M. G. André. Besides these reports, the volumes contain an account of several earlier investigations by M. Berthelot. We have in fact brought before us the whole of his investigations on plants, soils and various cognate matters, carried out during the last forty years.

Agricultural chemists will heartily welcome the publication in such a convenient form of this great mass of original investigation. M. Berthelot is well known as a first-class man of science, and as one of the most prolific and versatile workers of the present age. The new ideas he has brought forward concerning many obscure points in agricultural chemistry will be highly valued. Nevertheless, those acquainted with the peculiarities of M. Berthelot's work will not be surprised that a cautious critic is unable always to accept the conclusions to which he has apparently too easily arrived. The more startling and novel are the conclusions brought before us, the more thorough and unmistakable ought surely to be the basis of fact on which these conclusions are built. A few experiments, relating to only a part of the facts in question, must fail to carry conviction when new laws are propounded, or we are asked to surrender as a mistake views previously arrived at after much patient research.

It will be gathered from what has just been said that the papers in the volumes before us are of unequal value. All the investigations are indeed highly suggestive, and no experimental investigator would desire one of them to be omitted; but students of agricultural chemistry will not unfrequently find it advisable to examine with much care the evidence brought forward before accepting all the conclusions of the author.

That we may do no injustice to the book we will, in the first place, call attention to the very valuable investigation upon the nature and properties of humus, which occupies more than one hundred pages in the fourth volume. The elucidation of the chemical nature of humus has been regarded as an almost hopeless problem by the ordinary agricultural chemist. Berthelot has brought to bear upon the subject the methods and conceptions of modern organic chemistry, and his work has resulted in a considerable increase to our knowledge.

Berthelot has carefully studied the composition and properties of the simple nitrogen-free humus obtained by boiling sugar with hydrochloric acid. It appears to be a mixture of a condensed anhydride and hydrate, the

simplest expression for the former being  $C_{18}H_{14}O_6$ . It swells up in water, forming a colloid body. It absorbs a considerable quantity of alkali from an aqueous solution. One-third of the potash or soda thus absorbed is permanently retained in a practically insoluble condition after long washing with water. Placed in contact with ammonia an insoluble amido-compound is produced, from which ammonia is not recovered by boiling with magnesia. The oxidation of humus under the influence of light, and its more rapid oxidation in the presence of alkali are also studied. The heat relations of the principal reactions have also been ascertained. All this is fundamental work of very great importance, and throws much light upon the behaviour and functions of humus in a soil.

The natural humus in soil is also studied, and the action of acids and alkalis upon it investigated. The gradual formation of ammonia when the nitrogenous humus of soils is boiled with weak acids, soluble nitrogenous compounds being simultaneously produced, is pointed out as in full agreement with the assumed amido nature of the humic matter. The humus of soils is, however, a very complex substance; it may contain a very distinct amount of sulphur, and even phosphorus, in a state of organic combination. It will certainly be a novel fact for most agricultural chemists to hear that a soil may yield 0.183 per cent. of phosphoric acid when boiled with strong hydrochloric acid, 0.222 per cent. when the silica has been entirely removed by hydrofluoric acid and 0.292 per cent. when the soil is burnt in oxygen gas and the products retained by sodium carbonate. The excess obtained by combustion in oxygen is regarded by Berthelot as representing the phosphorus in organic combination. This part of the subject clearly requires much further investigation. Phosphorus, if present, is possibly a survival of the nuclein occurring both in the animal and vegetable kingdom.

We take our next example from one of the less satisfactory of M. Berthelot's investigations, in which the evidence brought forward seems quite insufficient to warrant the conclusions which he seeks to establish.

He has determined the quantity of nitrates present in certain plants, and has conceived the idea that plants have the power of producing nitrates abundantly in their own tissues. This assumption, if proved, would clearly furnish an entirely new departure in vegetable physiology. One would have thought that to establish such an hypothesis the plant would have been grown in a medium supplying no nitrates; any appearing in the plant would then clearly be due to the work of the plant itself. M. Berthelot makes no such experiment. To establish his position, he grows the plant (borage or *Amaranthus*) in the open field, without any knowledge of the quantity of nitrates produced in the soil during the season of growth, and without taking into account the upward movement of subsoil water containing nitrates during the dry summer of his experiment. He is satisfied by ascertaining that on September 25 a square foot of soil contained only about 1/20 of the quantity of nitrate contained in the plant pulled up from it, and that a similar bulk of soil taken at the beginning of the season, from another part of the

field, contained a similar quantity of nitrate to that found in the exhausted soil around the plant at the end of the season. The next year he finds that the soil of the field, when deprived of vegetation, doubled its contents in nitrates between June 4 and "the end of the season"; but this rate of increase was insufficient to account for the nitrates found in the crop the *previous year*! Finally, to prove that the plant contains a nitrifying agent, a single experiment is made by introducing a fragment of the stem of *Amaranthus* into a flask containing 300 grams of sterilised and exhausted soil. At the end of eleven weeks six milligrams of saltpetre were found in the soil. A blank experiment, made with soil only, was for some reason only continued for six weeks.

Data such as these are quite insufficient to convince a critical reader. Our confidence in the investigation is not increased by reading that the growth of a *single* crop in the field diminished the nitrogen in the soil from '275 to '173 per cent., and the potash of the soil in the neighbourhood of the roots from '64 to '47 per cent. Nor by remarking that the same figures for nitrates in the soil are first quoted as kilograms, and are afterwards always spoken of as grams.

The whole of the first volume is occupied with an account of investigations on the fixation of atmospheric nitrogen by soil and plants. M. Berthelot has been a pioneer in this branch of inquiry. The peculiar function of the organism forming the nodules on the roots of leguminous plants is now universally recognised. A similar case of symbiosis between a nitrogen-assimilating organism and certain algæ is also well known. Not so well known is the isolation of a bacillus from the soil by Winogradsky, which when supplied with sugar, and protected from the action of oxygen, is capable of assimilating atmospheric nitrogen. This organism succeeds in assimilating nitrogen from ordinary air when it is associated with ærobic organisms which appropriate the oxygen, and thus produce conditions suitable for the growth of the bacillus assimilating nitrogen.

Both in the case of the reaction in the leguminous rootlets and algæ, and in the case of the reaction *in vitro*, studied by Winogradsky, we have a clear indication of the source of the chemical energy which accomplishes the difficult task of bringing nitrogen into a state of organic combination; in every case we have carbohydrates abundantly present, and in Winogradsky's experiments we have a demonstration that the quantity of sugar fermented is a measure of the quantity of gaseous nitrogen assimilated.

With this principle before us we should suppose that a soil entirely destitute of vegetation could fix nitrogen only at the expense of its own organic matter; carbon would, in fact, be lost in the operation of fixing nitrogen. If, on the other hand, certain green algæ or leguminous plants were present, fixation of nitrogen might be accompanied by an actual gain of organic matter.

According to Berthelot's experiments, soils destitute of visible vegetation may gain large quantities of nitrogen when exposed to air. Even subsoils of argillaceous sand or clay, containing mere traces of carbon or nitrogen, are capable of gaining considerably in nitrogen when exposed to air. From an agricultural point of view, the quantities of nitrogen fixed are very considerable. Layers,

7 inches deep, of three surface soils from Meudon, fixed in 11 weeks from 70 lbs. to 130 lbs. of nitrogen per acre, quantities equivalent to 6-11 tons of farmyard manure. If this enrichment of soil by mere exposure to air is a fact, we shall be very anxious to know what are the precise conditions and limitations of such a beneficial action. Scientific agriculturists will be loath to admit that the exposure of a soil uncovered by vegetation tends to its permanent enrichment; the process of weathering tends, on the contrary, to the exhaustion of soil capital, and not to an increase of nitrogenous organic matter.

Berthelot's trials of various organisms yielded results of a similar favourable character. Out of seven organisms tried five produced an active fixation of nitrogen. The composition of the medium was apparently indifferent, for a mixture of certain bacilli from soil with kaolin determined an increase of 32 per cent. of the original nitrogen in one case, and an increase of 150 per cent. in another. Among the organisms fixing nitrogen, Berthelot includes the common mould *Aspergillus niger*.

In the last section of this volume Berthelot describes experiments which lead him to the conclusion that the natural electrical conditions, both of soil and plant, aid in bringing about the fixation of nitrogen from the air.

It is to be regretted that the large amount of work contained in these volumes is not of a more thorough and definite character, but we are very thankful that the investigations have been published. R. W.

#### OUR BOOK SHELF.

*Bird Life in an Arctic Spring; the Diaries of Dan Meinertzhagen and R. P. Hornby.* Edited by Mrs. G. Meinertzhagen. Pp. iii + 150. Illustrated. (London: Porter, 1899.)

A PATHETIC interest attaches to this volume, as being practically a memorial to a most promising and talented young ornithologist, whose life was unhappily cut short almost at the outset of his career. The late Mr. D. Meinertzhagen was essentially a lover of bird-life, and thus a naturalist in the very best sense of that somewhat abused word. But he was much more than this, being an artist of great talent, whose sketches and etchings of birds form some of the most beautiful delineations of feathered life it has been our fortune to see. In addition to those illustrating the text itself, nearly thirty of these talented sketches have been photographically reproduced as an appendix to the present volume, and serve not only to enhance the general interest of the latter, but likewise to convey an excellent idea of the artistic capacity of the author of the journal which constitutes its main claim to attention.

As we gather from the preface, the book is mainly intended for private circulation, and only a limited number of copies are offered to the general public. On the whole, the editor has exercised a wise discretion in endeavouring to preserve the journal of her son as much as possible in its original form, although it must be confessed that a little fuller supervision on the part of a trained ornithologist than has been permitted would have been advantageous in a few instances.

The journal is divided into two portions, the first and longer by Mr. Meinertzhagen, and the second by his companion Mr. Hornby. The trip to Lapland, of which these form the chronicle, was undertaken in 1897; and the journal of the originator breathes out the enthusiasm of an ardent bird-lover. The two companions appear to have visited spots to which few if any Englishmen