AGRICULTURAL CHEMISTRY AND VEGETABLE PHYSIOLOGY.

DURING the year 1910 no outstanding paper has been published comparable to Russell and Hutchinson's work which appeared during 1909, but activity has been well maintained in all departments of the subject, and particularly in connexion with Vegetable Physiology several valuable and suggestive investigations have been reported. No additions have been made during the year to our knowledge of the action of protozoa in the soil, although several independent investigators have arrived at results which fit in with the theory outlined by Russell and Hutchinson, and in a general discussion on the subject which took place at the Sheffield meeting of the British Association some promising applications to practice were reported in connexion with the treatment of greenhouse soils which, although rich in manure, rapidly become unsuited for vegetation, and again in connexion with the treatment of the soil of sewage farms. In the latter case, it is well known that after the use of excessive quantities of sewage the soil ceases to function in purifying the effluent, and this seems to be connected with such a development of protozoa under the favourable conditions that the bacterial actions are reduced to a minimum, although they may be rapidly restored by submitting the soil to some of the processes of partial sterilisation. One congress of some importance to agricultural science was held during the year, that on "Agro-geology" as a section of the International Geological Congress at Stockholm; there some interesting discussions took place on the classification of soils and on the limits of size to be adopted for the fractions into which a soil is divided by chemical analyses.

Soils.

In previous reports¹ I have discussed various points connected with the theory of soil productiveness and the action of fertilisers which has been advanced by Whitney and his colleagues of the Bureau of Soils in the United States Department of Agriculture,

¹ *Ann. Report*, 1907, 265 ; 1908, 246 ; 1909, 191.

but it has always been somewhat difficult to follow the progress of the work. In the first place, it has been printed piecemeal as it arose in the laboratory, and the bulletins are to be found in very few places in Great Britain. Secondly, they are written in a semi-popular style, so that the worker in the same field is rather apt to suspend his judgment until he can see a little more of the experimental foundation and criticise the data. At any rate, from one cause or another, the theory has received but little recognition in Europe, nor have the novel points of view advanced obtained the consideration they deserve. During the year, however, F. K. Cameron,² who has been associated with Whitney from the outset, has published a general survey of the whole field, and although the experimental data are necessarily omitted, the reader has now the theory set out in reasonable compass and accessible form, provided with references to the original papers that contain such data as have been given.

The author's main object is to controvert the general idea that the principal function of the soil is to supply nutrients to the plant, and that fertilisers are added to the soil to supply the nutrients which are lacking or in deficient quantity. He begins by discussing the rôle played by the water in the soil in its relation to the solids, and after dealing with the physical actions in which it shares, he takes as a starting point the conclusion that the plant draws its nutriment solely from the solution formed by the action of the soil water on the soil particles. Now Cameron concludes, on physico-chemical grounds, that this solution must be always of approximately the same strength, whatever the soil or whatever the treatment it has received in the way of fertilisers, because the addition of a few pounds of phosphoric acid to a hundred thousand times its weight of soil already containing two or three thousand pounds of phosphoric acid, and with an enormous absorbing power for that material, cannot influence to any sensible degree the concentration of the soil water in the phosphoric acid. Similarly with potash and the other mineral constituents of the plant. The amount of nitrogen in the soil solution is governed by other considerations, and in the main the argument refers to the mineral and not the nitrogenous nutrients of the plant. It is a difficult matter to obtain samples truly representing the soil water, but the evidence points to the extracts from all soils being of approximately uniform composition. Moreover, plants flourish in water cultures of extremely low concentration, far below that prevailing in any of the natural soil solutions, nor is growth accelerated by any increase in their strength.

² *J. Physical Chem.*, 1910, **14**, 320, 393; *A.*, ii, 646.

Putting aside the nitrogenous components, it would follow that all soils must behave alike as regards their power of supplying plants with their mineral constituents, and that mineral fertilisers can have no direct action in supplying the plant with its food. As this conclusion does not agree with experience, some other factor must be sought which determines the differences undoubtedly existing between the response of crops on particular soils to mineral fertilisers. The next step in the argument was the examination of aqueous extracts from various soils by the method of water cultures. It was found that plants would grow in these extracts, where they substantially behaved in the same relative fashion as when growing in the soils themselves, either in the field or in pots. The extracts from good soils yielded good plants, while the poor soils transmitted their indifferent crop-producing powers to their aqueous extracts. Nothing in the analyses of these extracts as regards their concentration in plant nutrients would account for the differences in growth exhibited; in fact, dilution of some of the poor extracts resulted in no falling off in growth, but at a certain stage even an increase. Hence the author concludes that the poor extracts and, in their turn, the poor soils contain certain toxic substances which inhibit the growth of plants. This was confirmed by finding that shaking up the poor extracts with such absorbent materials as animal charcoal, precipitated alumina, or ferric oxide made them capable of carrying good growth, although these substances could not possibly have added to the nutrients in the solution. Certain commercial fertilisers had the same beneficial effect on the solution, as had treatment with minute quantities of pyrogallol and lime. From this it was concluded that the toxic substances must be complex organic compounds, which are destroyed or precipitated by the treatment employed. A search was then made in some bad soils for organic materials of a toxic nature, and several such substances were successfully isolated; some of which proved to be toxic to plants in water culture. The author finally correlates the deterioration of soils under the continued growth of one crop with an accumulation of such toxic substances characteristic of a particular plant, and concludes that the value of rotation or a bare fallow or of the ploughing in of a green crop is due to the opportunities afforded for the oxidation or precipitation of the toxins. Furthermore, the usual fertilisers are considered to act indirectly in fitting the soil for the growth of crops rather than in the direct supply of plant food.

I do not propose to repeat here any of the criticisms which have from time to time been offered against some or other of the details of Whitney and Cameron's theory, of which the above is a very

summarised outline. One's general feeling is that nearly every step in the argument is open to some objection either as to fact or interpretation, and one doubtful deduction is based on another until the seeming logic of the whole argument leads to something like topsy-turveydom. Moreover, the final conclusion does not agree with field experience of the action of fertilisers, and it must be remembered that in Europe there is much more minute acquaintance with the effect of particular fertilisers on particular soils and crops than as yet prevails in America with its comparatively extensive methods of farming. It is probably the latter fact that has contributed so largely to the neglect of Whitney and Cameron's theory in Europe, but now that a general statement has been put together in an accessible form, it should receive the consideration of other soil chemists, for whatever their final conclusion about it may be, they cannot fail to find it stimulating and suggestive in a very high degree, suggestive, above all, in driving home the extreme complexity in the processes going on in the soil. It represents the final destruction of what we might call the old Liebig mineral theory, that the one thing needful to fertilise the crop was to put into the soil the substances the crop takes out; incidentally, also, the illusion that one can determine the available as distinct from the total plant food in the soil is again dismissed. This idea was proposed, only to be discarded by Daubeny seventy years ago, but, like so many mistaken points of view, it seems to possess perennial vitality.

Although no absolute distinction can be drawn between available and total plant food in the soil, the opinion continues to grow that information that is of value towards forming an opinion of the fertiliser needs of the soil can be best obtained by a determination of the amount of phosphoric acid and potash soluble in an aqueous solution of carbon dioxide, which is, after all, the chief solvent naturally at work in soils. In this connexion, E. A. Mitscherlich³ has published a critical study on the solubility in water containing carbon dioxide of the materials present in fertilisers and soils. He ascertained the influence on the resulting concentration of such factors as time, temperature, proportion of carbon dioxide, and the ratio of the amount of solvent to that of material. The results do not, however, permit of summarisation, but should receive the attention of workers in this subject. In another paper the same author⁴ investigates the question of whether crop production is influenced at all by the strength of the soil solution in carbon dioxide, which in the laboratory determines its solvent power over minerals. He arranged a series of pot experiments of given soils and manures,

³ *Landw. Jahrb.*, 1910, **39**, 299.

⁴ *Ibid.*, 157; *A.*, ii, 236.

watering some with tap water and others with water containing various amounts of carbon dioxide, but obtained no increased yield for the carbon dioxide. He concludes that a small amount of carbon dioxide is sufficiently effective, and that under natural conditions there is always a sufficient production from the roots and from the oxidation of organic matter, hence the application of fertilisers designed specially to increase the amount of carbon dioxide in the soil gases is needless. The use of carbon dioxide saturated water as an analytical agent to deal with soils is also recommended by Biéler-Chatelan.⁵

Arising out of his work with Hutchinson on protozoa, E. J. Russell⁶ has investigated the amount of ammonium compounds present as such in soils. Considerable uncertainty attaches to the determinations of ammonia in soils, because in the methods usually adopted the alkali attacks some of the organic nitrogen compounds, and there is a continuous evolution of ammonia as long as the distillation is continued. Russell finds that distillation with alcoholic potash (0.5 to 1.0 per cent.) at reduced pressures (32—35 mm.) shows a sharp end-point at which the evolution of ammonia ceases, and for soils not too rich in organic matter the same end-point is reached by a single distillation with magnesia and water at the same low temperature and pressure. This point Russell considers to represent the conclusion of the evolution of the nitrogen in the soil that was combined as ammonia. Only one or two parts of ammonia per million of soil are found in ordinary soils, rising in very rich garden soils to five or six. This is because the ammonia is kept down to a low limit by its conversion into nitrate by the nitrifying organisms. Thus under field conditions the factor limiting the formation of nitrates is really the preliminary ammonia producing process, and instead of the rate of nitrification it is really the rate of ammonia production that determines the amount of nitrogen available for the crop.

As bearing on the soil materials available for growth, S. U. Pickering⁷ has continued his examination of the chemical changes brought about by heating the soil for a short time to various temperatures above and below 100°. He confirms his previous results, that at all temperatures, but especially at 100° and above, there is a considerable formation of soluble organic matter which will serve as plant food, but is toxic in its nature, as shown by its injurious action on the rate of germination of seeds. This injurious material, however, gradually decomposes, probably by oxidation, because the injurious effect disappears when the soil in a moist condition is exposed to the air even under aseptic conditions.

⁵ *Compt. rend.*, 1910, **150**, 716; *A.*, ii, 453.

⁶ *J. Agric. Sci.*, 1910, **3**, 233; *A.*, ii, 1104.

⁷ *Ibid.*, 258.

E. J. Russell⁸ has also been working at the often debated question of the value of earthworms in cultivated soils. They have generally been regarded as increasing the productiveness of soil by decomposing the organic matter and preparing it for the action of the micro-organisms. Russell shows that previous experimenters have been misled by the nitrogen introduced into the bodies of the earthworms themselves; when this is allowed for, they seem to have no particular effect on the decomposition of organic matter and the production of nitrates. They have, however, considerable effect as cultivators, loosening and mulching the soil, and this may ultimately bring about some action on its fertility, although experimental demonstration would be difficult. Among the papers dealing with soil materials, mention may be made of one by H. Mieth,⁹ who tried a series of vegetation experiments in which he employed calcium silicates as sources of calcium. He found that plants easily decompose such precipitated silicates and can take up the calcium from them, so that these compounds may serve as sources of calcium to the plant instead of the carbonate, and this fact the author correlates with the maintenance of neutrality in many soils which show on analysis only a trace of calcium carbonate.

H. E. Annett¹⁰ reports an interesting fact regarding the colour of certain black cotton soils which occupy an area of over 200,000 square miles in India. These soils are not rich in organic matter, and remain black after oxidation with sulphuric acid. The colour proves to be due to a large extent to a black magnetic compound containing 73 per cent. of ferric oxide and 18 per cent. of titanium dioxide.

Soil Bacteriology.

In the domain of soil bacteria, no very novel work is reported. A. Koch¹¹ has continued his work on the power of *Azotobacter* to accumulate nitrogen in soils to which sugar and other carbohydrates have been added, and has obtained further results in confirmation of those previously reported. He has extended his experiments to small plots of soil, half a metre square, in the open air, and after treatment with sugar he has found that he obtained an increase of crop, which, although slight in the first year, was considerable in the second and third after application. From other sources we have evidence that the fixation of nitrogen by *Azotobacter* in the open ground is much affected by the prevailing temperature; if

⁸ *J. Agric. Sci.*, 1910, **3**, 246.

⁹ *Landw. Versuchs.-Stat.*, 1910, **74**, 81; *A.*, ii, 1105.

¹⁰ *Mem. Dept. Agric., India*, 1910, **1**, 185; *A.*, ii, 535.

¹¹ *J. Landw.*, 1909, **57**, 269; *A.*, ii, 60.

this be too low, other organisms than the *Azotobacter* predominate as a result of the carbohydrate application. Koch has added one further link to the completeness of the demonstration by showing that the addition of sugar to soils destitute of the *Azotobacter* organisms results in no increase in their content of nitrogen.

Koch¹² has also studied afresh the denitrification process in soils, and finds that there is but little loss of nitrogen, although both nitrate and dextrose had been added, provided the amount of water in the soil is kept down. For example, when the water in a particular soil was below 18 per cent., there was no reduction of nitrate, but when it rose to 25 or 30 per cent., denitrification set in. In other words, anærobic conditions must be established before the reducing organism comes into play.

Chemistry of the Growing Plant.

One of the most suggestive papers of the year is that published by H. E. and E. F. Armstrong¹³ on the action of chloroform and similar substances in stimulating enzyme action in living structures.

Starting with the interesting observations of Guignard and of Mirande,¹⁴ on the action of chloroform and similar anæsthetics on the development of hydrocyanic acid from cyanogenetic glucosides in the leaves of laurel and similar plants, the Armstrongs have proceeded to generalise the phenomena there described. They make use of the method discovered by Guignard, in which the green leaf is placed in a test-tube with a strip of paper coloured orange-yellow with a solution of sodium picrate. The liberation of a trace of hydrocyanic acid results in the production of successively orange, rose, and finally a dark brick-red colour on the test paper, due to the formation of sodium isopurpurate. Using leaves of the cherry-laurel (*Prunus laurocerasus*), which contains the glucoside *pru-laurasin*,¹⁵ no hydrocyanic acid is developed when the leaf and test paper are alone in the tube, but the addition of a drop of chloroform is followed in the course of a few minutes by a gradual development of colour, the action being more rapid at higher temperatures.

It was found the solutions could be substituted for the vapour, because sound leaves, partly immersed in water, give no hydrocyanic acid in three or four days. The experiments then showed that the vapours of ammonia, carbon disulphide, chloroform, toluene, ether, and various alcohols were quickly active, benzene, naphthalene, thymol, acetic acid were less so; carbon dioxide, benzene,

¹² *Centr. Bakt. Par.*, 1910, ii, 26, 335; *A.*, ii, 333.

¹³ *Proc. Roy. Soc.*, 1910, 82, B, 588; *A.*, ii, 883.

¹⁴ *Compt. rend.*, 1909, 149, 91, 140; *A.*, 1909, ii, 823, 824.

¹⁵ Caldwell and Courtauld, *Trans.*, 1907, 91, 671.

limonene were only slowly active. In solutions few salts had any action except in strengths that destroyed the leaf, but solutions of sodium or potassium fluorides were active, as were solutions of mercuric chloride and cadmium iodide and of ammonia, but not of potassium or sodium hydroxides.

These results fall into line with the well-known work of A. J. Brown¹⁶ on the semi-permeability of the membrane surrounding the barley grain, and indicate that only those substances are active which succeed in penetrating into the leaf. The authors propose to extend Starling's term of "hormones" to these excitants, and they point out that they are all substances with but slight attraction for water; materials which react with water generally fail to penetrate the leaf.

It is generally considered that in plant tissues the enzymes and glucosides are either contained in different cells or in different vacuoles in the same cell. Guignard states that in the cherry laurel the enzyme is stored in the endodermis, whilst the glucoside is in the parenchyma, and as the enzyme is not diffusible, it is most probable that the glucoside is induced to travel to the enzyme.

The action is evidently bound up with changes in the concentration of the fluids within the leaf; in his paper Guignard compares the action to that of frost, which induces a concentration of the cell sap and at once sets up change. In the leaves exposed to vapours there is sufficient water to allow of the passage of the glucoside towards the "hormone" entering very close to the enzyme which lies near the exterior surface.

From solutions a considerable amount of water enters the leaf with the hormone, a leaf, for example, increases in weight by 20 per cent. after eighteen hours' immersion in chloroform water, whereas it only gains 5 per cent. after twenty-four hours in pure water, and 2 per cent. after forty-five hours in a 2 per cent. solution of sodium chloride.

The authors discuss these results in the light of H. E. Armstrong's theory of the constitution of water, and then proceed to show their application to a number of phenomena in the life of animals and plants. As regards plants, one of the most significant facts is that carbon dioxide itself acts as a hormone; it is easy to suppose that variations in the presentation of this substance to the cell may excite enzymic action in the direction of hydrolysis or the reverse, the most significant of the processes in the metabolism of the cell. Moreover, a slight initial excitation may be sufficient to set in motion considerable change, because many of the products of hydrolysis, for example, hydrocyanic acid and benzaldehyde, are

¹⁶ *Proc. Roy. Soc.*, 1909, **81**, B, 82; *A.*, 1909, ii, 386.

themselves hormones and would extend the action. In the living plant, the hormone-excited changes can never be so large as in the experiments on the detached leaves, for A. D. Waller¹⁷ shows that the leaf is killed within a minute of the action of the chloroform, as may be ascertained from the abolition of electrical response.

Doubtless from these experiments light will eventually be thrown on the physiological function of many of the ethereal oils, terpenes, and scents secreted by plants so normally that they cannot be without significance.

They also throw some light on the horticultural practice which has been worked out of recent years, by which plants like lilacs intended for forcing are exposed to the vapour of ether for twenty-four hours or so. After the etherising process, it is found that the plants can be forced into bloom a week or ten days earlier than would otherwise have been possible. As cold acts in the same way by altering the concentration of the cell sap, we may also correlate the similar acceleration of flowering that is induced by a preliminary cold storage before forcing, and, again, the well-known fact that potatoes which have been frozen become sweet through an accumulation of enzyme-produced sugar. In a paper on the ripening of premature fruit, A. E. Vinson¹⁸ shows that dates which have reached a certain stage of development can be made to ripen by exposure to certain vapours or solutions, practically the same substances which the Armstrongs have found to be active. Vinson similarly concludes that the ripening is brought about by the release of the intercellular enzymes through substances penetrating the cuticle and stimulating the protoplasm.

The field of work thus opened up is extremely suggestive, and promises not only to throw light on many of the processes of the living plant, but also to find certain immediate practical applications.

Various papers dealing with assimilation have been published during the year. S. B. Schryver¹⁹ has taken up afresh the work of Priestley and Usher on the photochemical formation of formaldehyde by chlorophyll. He finds that grass, when washed with warm water, yields no formaldehyde, but when the grass is extracted with alcohol and the dried extract is heated with ether, then formaldehyde can be detected. Hence he concludes that in living plants the chlorophyll contains formaldehyde in combination. He next obtained films of chlorophyll by evaporating a 1 per cent. solution in ether on glass slips at the ordinary temperature. These

¹⁷ *Proc. Roy. Soc.*, 1910, **82**, B, 574; compare *A.*, ii, 741.

¹⁸ *J. Amer. Chem. Soc.*, 1910, **32**, 208; *A.*, ii, 336.

¹⁹ *Proc. Roy. Soc.*, 1910, **82**, B, 226; *A.*, ii, 334.

were exposed to moist carbon dioxide and to air freed from carbon dioxide by soda-lime, both in sunlight and in the dark. No formaldehyde was detected after exposure in the dark, and very little on the slips which had been kept over soda-lime, but a distinct reaction was obtained in sunlight. Schryver concludes that chlorophyll can form formaldehyde directly, but that it rarely becomes sensible because it does not accumulate in the cell, since it is withdrawn to form sugars as fast as it is formed. He employed a sensitive form of Rimini's test for formaldehyde (phenylhydrazine hydrochloride with potassium ferricyanide and hydrochloric acid gives a brilliant magenta colour in presence of formaldehyde), which will detect one part in a million, and can be made quantitative.

Thoday²⁰ has examined in detail Sachs' method of measuring assimilation by the difference in dry weight of comparable areas in the two halves of a leaf before and after exposure to light. He has succeeded in improving the method by eliminating certain errors, particularly those due to shrinkage of area, to which the method is liable. He obtains rates of assimilation (17 milligrams per hour per square dcm.) even higher than those of Sachs, and much higher than those obtained by Brown and Escombe. The low figures of the latter workers he considers to have been due to the high temperature prevailing in the glass cases in which their leaves were confined, and to the resulting lack of turgor in the leaves which would result in only a partial opening of the stomata.

R. Willstätter²¹ and his colleagues have continued their investigations on the constitution of chlorophyll. They had before established the existence of two chlorophylls, one amorphous—a phytol ester containing one phytol residue and one methoxyl group for each magnesium atom—and the other crystalline, yielding, on hydrolysis, phæophorbin, which is a dimethyl ester. The authors have now examined the distribution of these chlorophylls in a number of plants from the various orders. From experiments with grass, plantain, and nettles, they find that the nature of the chlorophyll is not influenced by the soil or the time of the year. The amorphous phytol ester, chlorophyll, is widely distributed and preponderates in some cases. Crystalline chlorophyll is not always found. Colorimetric determinations show that the leaves of various plants contain half to one per cent. of chlorophyll in their dry material.

The question of the action of small traces of metallic salts and other possible catalytic agents on the growth of plants has again received a good deal of attention during the year. For example,

²⁰ *Proc. Roy. Soc.*, 1910, B, **82**, 421; *A.*, ii, 800.

²¹ Willstätter, F. Hocheder, and E. Hug, *Annalen*, 1910, **371**, 1; *A.*, ii, 150.

in the Rothamsted Laboratory, W. E. Brenchley²² has examined in considerable detail the effect of the sulphates of copper and manganese on the growth of barley in water cultures. It has been maintained that all substances toxic to plants act as stimuli at some stage of high dilution, but with copper sulphate the author can find no evidence of stimulus even down to a dilution of one part in 10 millions of water. The toxic effect was always manifest, although it was greatly reduced when the copper was added to a solution of nutrient salts and not used in water alone. In the latter case, seedlings are very susceptible, being checked and even stopped in growth by the use of water which has been distilled from the ordinary copper vessels in the laboratory. The stimulus effect which had been reported from time to time may have either been due to accidental variations, since the individuality of plants grown in water cultures is very marked and large numbers must be taken in order to obtain smooth results, or else to some secondary action of the toxic substances on bacteria, etc., in the culture medium. Manganese sulphate can hardly be regarded as toxic for barley; although in moderate concentrations (more than one in 10,000) there was retardation of growth, at lower concentrations, one per 100,000 and downwards, there was distinct evidence of stimulus. Incidentally it was noted that at such concentrations as one per 10,000, the manganese taken up by the plant was excreted as peroxide on the surface of the leaves. As manganese is usually found in plant ashes, and has been considered by Bertrand and his co-workers to aid in the action of the oxydases of the leaf, it obviously stands in a different position, and cannot be compared with substances like copper which are toxic and have no normal physiological function.

In the same line of work comes a paper by P. Ehrenberg²³ on the effect of zinc salts on vegetation. Zinc he finds to be always toxic when the action is simply between the plant and the reacting substance. In his experiments on soil, however, cases were met with of apparent stimulus due to zinc, but the author considers that these can always be explained by some indirect chemical or biological action of the zinc on the constituents in the soil, rather than to any stimulating action of the toxin on the plant. Ehrenberg concludes that zinc vessels ought never to be used in vegetation experiments, although one of the most commonly employed types of vessel for pot culture work is made of zinc.

P. Koenig²⁴ also reports a long series of experiments on the action of chromium salts on vegetation, in which he claims to

²² *Ann. of Botany*, 1910, **24**, 571; *A.*, ii, 889.

²³ *Landw. Versuchs.-Stat.*, 1910, **73**, 15; *A.*, ii, 236.

²⁴ *Landw. Jahrb.*, 1910, **39**, 775.

demonstrate that both the chromium salts and the chromates, although normally toxic, may act as stimuli. The conclusion as to stimulus is, however, vitiated by the fact that the additions of chromium were always made to soil in which the test plants were growing. So involved are the actions taking place in the soil, the resultant only of which is represented by the growth of the plant, that one has no right to draw any conclusions from such experiments as to the direct action on the plant of the material under investigation.

Amongst other work dealing with the living plant which possesses some economic interest is a paper by Otto and Kooper²⁵ on the changes of the composition of fruit as it ripens after gathering. The experiments were made with sloes, and the authors found that in the ripening process the lævulose increased while the dextrose decreased, and during the same time both the acids and the amount of tannin markedly decreased. The decrease in acid and tannin was larger than the net increase of sugar, the difference no doubt representing losses by respiration, and the authors considered that the other figures indicated a change from dextrose to lævulose, a change, however, which is very difficult to credit.

Another paper, although a contribution to the study of genetics, is yet of general interest to plant-physiologists because of its possible bearing on enzyme actions in living plants, is one by M. Wheldale²⁶ on the inheritance of colour in certain sweet peas and stocks. In these flowers the colours are due to anthocyanins, which are the oxidised products of the action of an oxydase on a chromogen. Both must be present in the same flower to cause colour, but as all the white flowers contain the chromogen, their absence of colour must be due to a lack of one or other of the factors (peroxide and peroxydase) making up the oxydase system. Investigations of white flowers which on mating will yet throw coloured blooms confirmed this theory; in the extracts of some of the white flowers no evidence of oxydase was found, whilst in others the peroxide factor was lacking. The two factors are inherited separately on Mendelian lines, and, on mating, coloured flowers may be produced when the two factors are again united in the same cell.

Manures and Manuring.

During the year little work on fertilisers has been reported beyond the usual stock experiments on the effect of these materials when used with different crops and soils. Various new materials have

²⁵ *Zeitsch. Nahr. Genussm.*, 1910, **19**, 10; *A.*, ii, 233.

²⁶ *Roy. Soc. Report to Evolution Committee*, 1909, V, 26; compare *A.*, 1909, ii, 604.

been brought forward, but none of them represent any fresh development or utilisation of a novel principle as did the nitrogenous manures generated from the atmosphere. In the latter connexion, the changes taking place when cyanamide is applied to the soil continue to attract a good deal of attention, and C. Ulpiani²⁷ gives an account of a long series of experiments on this question. He dismisses the idea originally suggested by Löhnis that bacterial actions play any considerable part in breaking down the cyanamide to the stage of ammonia. He regards the action as chiefly brought about by the colloidal surface of soil particles, which acts as a catalyst. The change ceases when this is destroyed either by heating the soil or by treating with acids or alkalis, but can be restored by the addition of precipitated silica. The cyanamide changes first into carbamide, and then into ammonium carbonate, but Ulpiani can find no evidence for Löhnis' idea that a formation of ammonium cyanate precedes the carbamide. The change takes place in the presence of antiseptics and with sterilised materials; it also goes on with increased velocity at 100°; again it is most rapid at first, and then falls off. It also increases with the concentrations of the solutions taken. None of these facts agrees with the theory that the change is brought about by bacteria. The soil absorbs the ammonia as it is formed, and this removal of the products accelerates the rate of change, and also prevents polymerisation into dicyanodiamide. Because of the susceptibility of cyanamide to change in moist air and the formation of the toxic dicyanodiamide, C. Brioux²⁸ has worked out a method for the analysis of the altered product. This method depends on the fact that the precipitate which cyanamide gives with silver nitrate is insoluble in ammonia, whereas the precipitate similarly formed by dicyanodiamide is soluble.

Methods for the estimation of nitrates continue to attract a good deal of attention, because the determinations with the nitrometer or as nitric oxide by Schloesing's process are not particularly convenient. It is obviously preferable to reduce the nitrate to ammonia, which can be rapidly and accurately measured by the routine methods of the laboratory. M. E. Pozzi-Escot²⁹ employed for this purpose aluminium, together with a little mercuric chloride, so as to form an aluminium-mercury couple which reduces the nitrate to ammonia in a few minutes. This method has, however, been severely criticised; Cahen³⁰ dismisses it as untrustworthy, and would replace it by Devarda's method, in which the reduction is effected by 2 or 3 grams of alloy containing 45 per cent. of

²⁷ *Gazzetta*, 1910, **40**, i, 613; *A.*, ii, 890.

²⁸ *Ann. Chim. anal.*, 1910, **15**, 341; *A.*, ii, 1010.

²⁹ *Bull. Assoc. Chim. Sucr. dist.*, 1909, **27**, 457; *A.*, ii, 71, 153, 652.

³⁰ *Analyst*, 1910, **35**, 307.

aluminium, 5 of zinc, and 50 of copper. This is digested with the nitrate-containing material for half an hour in the presence of concentrated sodium hydroxide, the digestion flask being connected from the outset by the distilling apparatus. The distillation is then completed and the ammonia collected in the standard acid as usual.

J. M. Wilkie³¹ has discussed a method of determining ammonia, which may on occasion become useful to the agricultural analyst. The solution is rendered exactly neutral, and neutral formaldehyde is added. The acid which results from the abstraction of the ammonia by the formaldehyde is titrated with baryta water, using phenolphthalein as indicator.

Chemistry of Animal Nutrition.

Papers dealing with animal nutrition have been rare in this country, but there are not wanting indications that work on this important subject is beginning in Britain, and we are pleased to be able to report on one interesting piece of work that has appeared during the past year. In some earlier papers, T. B. Wood³² has shown that certain constant differences exist in the composition of the various kinds of mangolds usually grown. Their average content of dry matter varies from 10·7 per cent. in the "Yellow Globe" to 13·1 per cent. in the "Long Red" and yellow-fleshed varieties. Since the "Long Red" yields on the average as large a crop as the "Yellow Globe," and a much larger one than the yellow-fleshed varieties, it produces the most dry matter per acre, and should be the most profitable mangold to grow. To make this conclusion valid, however, it was necessary to show that the dry matter of the "Long Red" variety possesses equal feeding value to that of the others, and accordingly the author carried out a series of seven experiments on fattening cattle, using thirty-seven animals in all, comparing in each case the effect of equal weights of "Long Red" and "Yellow Globe" mangolds. The final result shows a superiority of the "Long Red" as compared to the "Yellow Globe" of 116 to 100 in their power of producing live-weight increase, the proportion of dry matter being as 120 to 100. Two other experiments showed that "Long Red" and yellow-fleshed mangolds possess equal feeding values, the percentages of dry matter being approximately the same in the two varieties. The limits of experimental error obtaining in the trials are discussed, and the final result may be taken as conclusive that the feeding value of the mangold is determined as

³¹ *J. Soc. Chem. Ind.*, 1910, 29, 6; *A.*, ii, 240.

³² *J. Agric. Sci.*, 1910, 3, 225.

closely as it can be measured in practice by the percentage of dry matter in the roots.

In the field of animal nutrition interest is now chiefly fixed on the proteins and their cleavage products, as it is felt that the main lines of the energy question are settled. Abderhalden³³ and his co-workers continue to improve upon their attempts to feed animals with the cleavage products instead of the proteins themselves, and have now attained a much greater measure of success. They found that dogs could maintain their nitrogen equilibrium on the deficient cleavage products of meat, whether hydrolysed by pepsin, trypsin, and erepsin, or by acid, provided that care was taken to remove the traces of barium which acted prejudicially in their former experiments. When the products of acid hydrolysis are administered, it is desirable to add tryptophan, because this substance is to a large extent destroyed by the acid.

Osborne³⁴ has continued his work on the cleavage products of proteins, and in an important paper, in which he sets out as fully as possible the cleavage products of zein, he shows a recovery of something like 80 per cent. He discusses at length the sources of loss which still exist in all methods of protein hydrolysis.

Kellner³⁵ has continued his work on the value of non-protein nitrogen compounds in the nutrition of ruminant animals. Lambs were fed as to their nitrogenous requirements exclusively on asparagine and ammonium acetate. The result showed that these substances can be so converted by the bacteria of the intestines into protein that they can replace some of the protein required for maintenance. There was, however, no evidence of production of flesh from these non-proteins, but when fed together with protein they can increase the formation of flesh by saving the protein required for maintenance. The same question has also been investigated at the Hohenheim station,³⁶ where ammonium acetate and asparagine were fed to milch cows. The authors conclude that these substances do not lead to any increase in the undigested protein in the faeces, although they are converted by bacterial action into proteins which may be utilised by the animal, not merely for maintenance, but also for milk production.

Among other papers interesting to the agricultural chemist is one by Siegfeld³⁷ on the constitution of butter fat. He finds that

³³ *Zeitsch. physiol. Chem.*, 1910, **64**, 158; *A.*, ii, 322.

³⁴ T. B. Osborne and L. M. Liddle, *Amer. J. Physiol.*, 1910, **26**, 295 *A.*, i, 598.

³⁵ O. Kellner, P. Eisenkolbe, R. Flebbe, and R. Neumann, *Landw. Versuchs.-Stat.*, 1910, **72**, 437; *A.*, ii, 424.

³⁶ A. Morgen, C. Berger, and F. Westhausser, *ibid.*, **73**, 285.

³⁷ *Milchw. Zentr.*, 1910, **6**, 122; *A.*, ii, 327.

tributyryl is soluble in alcohol, by which it can be extracted from a mixture of beef butter. Butter, however, yields very little fat to alcohol, and that of much the same composition as the original fat: from which he concludes that Bell's original conception of butter fat as mixed glycerides is most likely to be correct.

T. Weyl³⁸ has examined the precipitation of proteins by acetone as a basis for analytical processes. He finds that acetone precipitates the protein from milk completely; the milk is diluted with an equal volume of water, four volumes of acetone are added, and the collected precipitate, after washing, is extracted with ether, dried, and weighed. It is possible that this method of precipitating proteins with but little change may become useful in plant analysis.

As regard the nutrition of farm stock, the most notable event of late years has been the introduction of the soya bean from Manchuria, and the considerable trade in soya bean cake which has thus developed. Although the ordinary analyses show that one was dealing with a very rich material, only paralleled by decorticated cotton cake, direct experiments on its digestibility were not available, but one had to assume that it would probably fall into line with similar concentrated foods and prove very completely digestible.

F. Honcamp³⁹ now reports certain determinations of the digestibility by sheep of soya bean meal, made both from the pressed cake and from the residue after the oil had been chemically extracted. The following table will show that the meal is the most concentrated of all feeding stuffs in common use, with the exception of linseed from which the oil has not been extracted:

	Press cake.		Residue.	
	Total.	Digestible.	Total.	Digestible.
Crude protein	47·9	43·3	52·2	48·0
Nitrogen-free extract ...	32·8	31·1	34·6	34·6
Crude fat	7·9	6·9	1·8	1·2
Crude fibre	5·6	4·4	5·3	5·2
Starch equiv.	92		86	

It has long been recognised that a certain amount of care must be exercised in feeding stock with cottonseed cake; from time to time injurious results have been reported, as though the feeding stuffs contained some toxic substance, but the experiences were not consistent, and attempts to isolate a poisonous constituent have not been successful, although cholin and betain have been found and credited with the harmful action. In practice farmers have found it wise not to feed cotton cake to milch cows near calving,

³⁸ *Ber.*, 1910, **43**, 508; *A.*, i, 287.

³⁹ *Landw. Versuchs.-Stat.*, 1910, **73**, 241.

nor to young stock. A. C. Crawford,⁴⁰ after a series of chemical and physiological experiments, now attributes the toxic results to salts of pyrophosphoric acid, the compounds being in some meals inorganic, in others probably organic. Seed of upland cotton is more generally poisonous than that from Sea Island cotton, although the latter becomes toxic if it is heated in the process of extracting the oil, due to the conversion of ortho- into pyro-phosphates.

Crawford's conclusions seem to be well supported by his experimental work, and it should be noted that at least one previous worker has found pyrophosphates in cottonseed meal and has drawn attention to their poisonous character.

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⁴⁰ *J. Pharm. Exp. Ther.*, 1910, **1**, 519.