

AGRICULTURAL CHEMISTRY AND VEGETABLE PHYSIOLOGY.

THE record of the year includes no notable discovery nor any paper that is likely to be reckoned in the future as of fundamental importance; in several directions, however, good progress has been made, although, as the subject opens up, it is only to disclose its increasing complexity. Agricultural chemistry is essentially a border-line science, dwelling on the confines of chemistry and physics, botany, and physiology alike, touching these subjects also just where they are most difficult and obscure. The chemistry of the growing plant and of the feeding animal is the chemistry of the proteins and the carbohydrates, of enzyme action, and of the varied functions of the cell, whilst the study of the soil at once leads to some of the most difficult problems of solution, and of the interaction of molecular and chemical forces which take place in the thin films surrounding the soil particles.

Soil Bacteriology.

Considering first the soil, the part played by the organisms contained therein assumes every year a greater importance; it becomes increasingly evident that plant production in the open field, and the effect of fertilisers and even of cultivation, are determined by the nature of the soil flora and the repression or encouragement of particular groups of micro-organisms. The free organisms in the soil that can fix atmospheric nitrogen continue to receive considerable attention, and the chief conditions of their activity—a supply of oxidisable carbohydrate, from which they may derive the necessary energy, and the presence of calcium carbonate to neutralise the acids produced—may be regarded as established; it is the magnitude of the part played by *Azotobacter* and its congeners, under natural conditions, that remains to be determined. A. Koch and his colleagues at Göttingen¹ show that the addition of dextrose, sucrose, soluble starch, or straw to soil brings about an increase in the amount of nitrogen it contains;

Abstr., 1908, ii, 56.

the best effect was obtained by a single application of 2 per cent. of dextrose, when 8 to 10 milligrams of nitrogen were fixed for each gram of sugar added. They also showed that the nitrogen compounds formed by the *Azotobacter*, the chief organism concerned, were easily nitrified; as a consequence, when sugar was added to soil in pots in which successive crops of oats and buckwheat or sugar beet were grown, the nitrogen fixation induced by the sugar became evident in an increased yield. The first crop of oats was reduced, the unchanged sugar acting injuriously on the growing plant, but in the following year the yield of buckwheat or beet was much increased, being nearly trebled where 4 per cent. of sugar had been added. At the end of the experiment, the sugar-treated soil was also found to have been enriched in nitrogen. That the depression of the first crop was due to the injurious effect of the unaltered sugar was shown by another experiment, in which the soil, after the addition of the sugar solution, was kept in an incubator for four weeks. Oats were then sown, which yielded more than double the amount of dry matter that was obtained in the check experiments, where the soil received no sugar. These experiments constitute the first direct experimental demonstration that *Azotobacter* can play a practical part in provision of nutriment for the higher plants.

H. R. Christensen² has dealt with the importance of calcium carbonate and the phosphates in the nutrition of *Azotobacter*. He showed that the occurrence of *Azotobacter* in various soils stands in close relationship to the amount of calcium carbonate in the soil, exceptionally active soils always possessing an alkaline reaction, which confirms the observations of S. F. Ashby on the Rothamsted soils.³ He even considers that the growth of *Azotobacter* will form the most trustworthy evidence that can be obtained of the presence of traces of calcium carbonate in soils. J. F. Lipman⁴ also used *Azotobacter* as a test of the state of the mineral constituents of the soil, and reaches much the same conclusions as Christensen, whilst Wilfarth and Wimmer⁵ found the presence of phosphoric acid essential.

As regards fixation of nitrogen by the nodule organisms of the leguminosæ, no new step can be reported; various preparations of the organism are being widely used⁶ in a practical way for the inoculation of seed or soil before a leguminous crop, although the best way of preserving the cultures in an active condition has

² *Centr. Bakt. Par.*, 1907, II, 17, 109, 161, 378, 735.

³ *J. Agric. Sci.*, 1907, 2, 35.

⁴ *Report New Jersey Agric. Exp. Station*, 1907.

⁵ *Abstr.*, 1907, ii, 809.

⁶ See Remy, *Centr. Bakt. Par.*, 1907, II, 17, 661.

not yet been settled.⁷ But, although inoculations may be of the greatest possible benefit in introducing the appropriate organism into soils which have never previously carried the leguminous crop in question, such soils are exceptional, and it is not yet demonstrated that there is any return for the inoculation of ordinary cultivated land. It is uncertain whether more active races of the clover organism, for example, can be distinguished, and, further, it is uncertain if such improved races, when introduced into ordinary soil swarming with kindred organisms, can survive the competition that results, so as to produce any permanent effect upon the crop.

As regards nitrification, perhaps the most important of the bacterial processes in the soil, Kaserer⁸ reports the isolation of another bacterium, *B. nitrator*, which forms nitrates from ammonia in a single operation. Hitherto, no nitrifying organisms have been detected other than those first distinguished by Warington and then isolated and described by Winogradsky, *Nitrosomonas* and *Nitrosococcus*, which oxidise ammonia to nitrite, and the *Nitrobacter*, which completes the change to nitrate. Müntz and Lainé⁹ have been studying the nitrification process on a large scale to ascertain if the old nitre beds could be so far improved as to become practical sources of nitrate, supposing the conditions of a century ago were to recur and France were again cut off from any external supply of Chilian or Indian nitrate. Müntz obtained the most intensive nitrification when a weak solution of ammonium sulphate percolated through a layer of some medium offering a large surface, peat proving the most effective when an excess of calcium carbonate was maintained. The inhibiting effect of organic matter on nitrification does not hold for the humic compounds of peat. A strong solution of ammonium sulphate cannot be nitrified, but by repeatedly adding further small amounts to a solution that has already been oxidised, and passing it again through a nitrifying bed, the concentration of the calcium nitrate could at last be raised to about 4½ per cent. Some little time was necessary before the beds reached this efficiency, since the nitrifying organisms only gradually become habituated to working in solutions of such a concentration. In view of the rapid development of the electrical processes for making nitrates, it is improbable that Müntz's improved nitre beds will ever be required.

Perhaps the most interesting question in soil bacteriology which has of late been opened up, is concerned with the increased productiveness shown by soil that has been subjected to some process

⁷ R. G. Smith, *Abstr.*, 1907, ii, 498.

⁸ *Ibid.*, 381.

⁹ *Bull. Soc. d'encouragement pour l'Industrie Nationale*, 1907, 109, 951.

of partial sterilisation, such as heating to the temperature of boiling water, or treatment with volatile antiseptics like carbon disulphide or toluene. The facts have been disclosed in a more or less accidental fashion by various workers during the last ten years or so, but it is only just lately that they have attracted much attention, or have been seen to possess any general significance. Various papers on the subject appeared during 1907 (Heinze,¹⁰ Koch¹¹), including one by F. V. Darbshire and E. J. Russell,¹² which traverses the whole ground very thoroughly. In continuance of the work of these authors on the rate of oxidation in soils,¹³ they were led to observe that soils which had been heated to 100°, or treated for a time with volatile antiseptics, always showed a higher rate of oxidation than the same soils untreated. As they had previously established an interdependence between the rate of oxidation and the fertility of a soil, they proceeded to test the effect of such treatment upon the productivity of soils by means of experiments in pots. The soils were either heated for two or three hours to a temperature of 90—95°, or treated in their pots for about a week with a small quantity of carbon disulphide, toluene, or chloroform, after which they were spread out in thin layers until all trace of the antiseptic had volatilised; no trace of the antiseptic could be detected by any of the tests then applied. Various crops were grown in the pots, and in all cases the treated soil yielded a greater weight of dry matter than the untreated soil, the increase being generally from 10 to 40 per cent., but occasionally as high as 70 to 90 per cent. The beneficial effect of the treatment was also seen when a second crop was taken without further disturbance of the soil, but it did not extend to the third crop. Not only was the dry matter increased, but it was, as a rule, richer in nitrogen, phosphoric acid, and potash, so that the crop always removed larger amounts of these fundamental nutrients from the treated soil.

The result of heating the soil was even more marked; except in the case of certain leguminous plants, the yield of the heated soil was generally doubled or even trebled, and again the effect persisted to the second, and sometimes to further crops.

It is impossible to explain these results from a purely chemical point of view, for, even if the heating might be supposed to render more available the store of plant food in the soil, no corresponding action could be attributed to the vapour of toluene or chloroform. It was demonstrated that the soils were not completely sterilised by the treatment, and the most tenable explanation is that the

¹⁰ *Abstr.*, 1907, ii, 388, 502, 572.

¹² *J. Agric. Sci.*, 1907, 2, 305.

¹¹ *Ibid.*, 647.

¹³ *Ann. Report*, 1905, 251.

partial sterilisation exercises some selective action on the groups of bacteria in the soil, destroying some which are unfavourable to the growth of the plant, and thereby giving other beneficial forms, like the oxidising bacteria, a greater scope. One of Darbishire and Russell's experiments is rather significant in this connexion; they found that if they watered the heated soil with ordinary well-water, it lost some of its superiority over the untreated soil, thus indicating that the beneficial rearrangement of the original soil flora brought about by the partial sterilisation can only persist when the soil is watered with sterile water introducing no new forms.

With this work of Darbishire and Russell's may be connected an investigation by O. Rahn¹⁴ on the effect that drying soil at the ordinary temperature has on its bacteriological properties. Soil which had merely been allowed to dry was found to induce greater bacteriological changes, as, for example, production of acid in dextrose solutions, production of carbon dioxide in sugar solution containing calcium carbonate, formation of ammonia in urea or peptone solutions, than did the same soil after storage in a moist condition. These effects were most manifest with a rich garden soil, but it was not settled whether they were to be regarded as accelerations due to drying, or depressions brought about by storage in a moist state. The number of the bacteria (growing upon gelatine) in the soil was always diminished by drying, and the author considers that his results show the effects were due to some substance formed in the soil by drying, which is soluble, not decomposed by boiling its solution, and not of the nature of an ordinary plant nutrient. Experiments on the effect of a preliminary drying of the soil on mustard in pots were not conclusive.

The susceptibility of the soil to changes of this kind is a question still open to a good deal of elucidation, but it already promises results which may attain considerable practical importance; meantime, it also serves to emphasise the necessity for caution in drawing conclusions from any experiments on soil, when what is apparently so small a disturbance can bring about such a radical change in its productiveness.

Soil Chemistry.

In this section of our subject there is nothing novel to report, although Whitney and his colleagues of the Division of Soils (U.S. Department of Agriculture) have issued several bulletins,¹⁵ in which they continue to develop their somewhat remarkable theory of the functions of soil and fertilisers, a theory which has

¹⁴ *Centr. Bakt. Par.*, 1907, II, 20, 38.

¹⁵ See particularly Bulletins Nos. 36, 40, and 47.

found no acceptance, nor much consideration, among European chemists.¹⁶

Briefly, Whitney's theory is that soils become infertile through the accumulation of toxic substances excreted by the roots of crops, and that fertilisers act, not by directly feeding the plant, but by in some way destroying or putting out of action these toxic excretions. The experiments brought forward in support of this theory are chiefly made with wheat seedlings in water cultures, the seedlings being from six to twenty days old, and therefore still drawing their nutriment from the endosperm. The reports go to show that the growth of such seedlings in distilled water is injured by the addition of an aqueous extract of certain soils, but that the injurious effect of the extract can be removed by a preliminary filtration through finely-divided carbon, shaking up with ferric hydroxide or calcium carbonate, and, as a rule, by boiling. Other experiments showed that water in which such seedlings have been grown for a time acts injuriously on the growth of a new batch of seedlings, but that filtration through carbon, &c., as before, restores the water in which the seedlings have been grown to a normal condition suitable for renewed growth. Distilled water containing very small amounts of such plant products as neurine, guanidine, coumarin was also shown to be hurtful to the development of the seedlings, but was again improved by the treatment described before. Many questions suggest themselves in reading these interesting reports and the speculations they give rise to, but criticism is as yet impossible; the data supplied afford no means of estimating the magnitude of the experimental error, which is known to be great in experiments of this kind, and the experiments themselves are never pushed to the point of becoming really critical of the theory, the authors seeming to be content to multiply results "which may be explained by supposing," or are "in accord with the assumption upon which the experiment was made." Here, in Europe, we must suspend our judgment until we receive a more critical version of the work.

The perennial question of the most suitable solvent to use for the determination of the "available" mineral plant food in the soil continues to receive attention. E. A. Mitscherlich¹⁷ selected water saturated with carbon dioxide, which substance he regards as the main secretion of the plant's roots, and the effective solvent under ordinary soil conditions (see also Stoklasa, &c.¹⁸). He then proceeded systematically to the examination of one or two soils with the view of determining the effect of the concentration of

¹⁶ See, however, Pouget and Chouchak, *Compt. rend.*, 1907, **145**, 1200.

¹⁷ *Landw. Jahrbucher*, 1907, **36**, 309.

¹⁸ *Abstr.*, 1907, ii, 717.

the carbon dioxide in the solution, of the duration of the action, and of temperature, so as to arrive at the probable error attaching to estimations of this method. It is noteworthy that the temperature factor is considerable for the potash and nitrogen, but not for phosphoric acid or lime, although it has hitherto been neglected in considering these various methods of extraction of weak solvents. No attempt was made by Mitscherlich to correlate his results with the behaviour of the soils in the field; this, however, was the prime object of A. de Sigmond,¹⁹ who has examined Hungarian soils by an entirely different method. de Sigmond started from some experiments of Schloesing's,²⁰ who showed that if a series of samples of soil be attacked by very dilute solutions of nitric acid, the strength of which increases by steps, the amount of phosphoric acid dissolved increases at first with the strength of the nitric acid solution, then remains constant for a time, and then begins to rise again. This second increase, according to Schloesing, marks the point at which the nitric acid becomes more than strong enough to dissolve all the "available" phosphoric acid, so that it then begins to attack the more insoluble compounds present in the soil. de Sigmond generally discusses the results obtained by this method, which was thus tried for the first time on a large scale, and obtained a considerable agreement between them and the behaviour of the soils towards phosphatic fertilisers, as judged by a series of field and pot experiments, which are also reported.

Another question which dates back to the earliest days of agricultural chemistry, the withdrawal of ammonia from its compounds, and its retention by the soil, has been re-examined during the year by A. D. Hall and C. T. Gimingham.²¹ These authors found that the action was always one of double decomposition, either with the zeolitic double silicates of the soil, ammonium being withdrawn and an equivalent amount of calcium, magnesium, potassium, or sodium taking its place in the solution, or with humus (calcium humate), in which case an equivalent amount of calcium again replaced ammonium in the solution. No measurable amount of adsorption of the salt, as a whole, or of selective absorption of the base, so as to leave the solution acid, was observed, even when the solutions were evaporated at the ordinary temperature in a current of air, or exposed to the action of a stream of carbon dioxide. The authors give an empirical formula connecting the amount of change with the concentration of the ammonium salts in the solution when the amount of clay in equilibrium with the solution is in excess, but

¹⁹ *Abstr.*, 1907, ii, 717.

²⁰ *Ibid.*, 1899, ii, 449.

²¹ *Trans.*, 1907, 91, 877.

do not establish any theoretical justification for the formula arrived at. The authors also considered the interaction of ammonium salts and calcium carbonate, but showed that the presence of this constituent affects but little the removal of ammonia from solution by the clay and humus. They therefore regard the retention of ammoniacal fertilisers by the soil as due to clay and humus without the preliminary reaction with calcium carbonate that is sometimes regarded as necessary.

R. A. Robertson, Irvine, and Miss Dobson²² have begun a fresh study of humic acid, which they have extracted from peat, and also prepared by the action of hydrochloric acid on sugar. The elementary composition of the two products were compared, and, besides differences in the percentage of carbon, the natural acid always contained nitrogen, and probably iron. It yielded fewer methoxyl groups than did the artificial acid, and, when compared as a source of carbon for the growth of *Penicillium*, the artificial acid was better than the natural, but inferior to glucose. S. Suzuki²³ has also examined natural humic acid by hydrolysing it with strong hydrochloric acid; from the products, he isolated alanine, leucine, aspartic acid, and small quantities of proline and other amino-acids.

Several reports on the analysis, chemical and mechanical, of a series of English soils have been published during the year, and, as the analyses have been carried out on a uniform system, there is steadily being accumulated a mass of data for a general chemical survey of the soils of our country.

C. M. Luxmoore²⁴ described the composition, mechanical and chemical, of one hundred samples of soil and subsoil from Dorsetshire, the soils being derived from each of the tertiary and secondary formations between the Bagshot Beds and the Lower Lias; F. W. Foreman²⁵ dealt with soils from Cambridgeshire, generally derived from the same formations as those discussed by Luxmoore, and S. F. Armstrong²⁶ attempted to correlate the composition of a number of meadows and pastures in the eastern counties with the chemical and botanical composition of the herbage.

Soil Physics.

The physics of the soil is, perhaps, at the present time the most neglected branch of agricultural science, yet it ought to be very attractive to any investigator, if it were only for the bearing it has on the practical operations of cultivation and management of the soil, which are of such prime interest to the working farmer.

²² *Abstr.*, 1907, i, 894.

²³ *Bull. Coll. Agr. Tōkyō*, 1907, 7, 513. See also A. J. van Schermbeck, *Abstr.*, 1907, ii, 648.

²⁵ *J. Agric. Sci.*, 1907, 2, 161.

²⁴ *Report*, Reading University College,

²⁶ *Ibid.*, 283,

During the past year few papers bearing on this subject have appeared, nor has any new line of inquiry been opened up. Von Seelhorst and his colleagues at Göttingen²⁷ have continued their studies of the effects of variation in the water content and temperature of the soil on the composition and yield of various crops, the experiments in this case being made on oats and spring wheat.

R. S. Vinson and E. J. Russell²⁸ gave an interesting series of temperature readings to illustrate the well-known fact that the bottoms of valleys are colder than the slopes on either side. The results agree with the usual explanation that the cooled air flows down the sides and accumulates in the bottom of the valley, but they also indicate that the actual river bank is warmer than land a little further back from the water, the rise in temperature being particularly marked on any piece of land more or less surrounded by water.

Another perennial problem, the flocculation or coagulation by means of salts of turbid liquids, such as suspensions of clay in water, has again been dealt with by A. D. Hall and G. G. T. Morison.²⁹ These authors have endeavoured to obtain quantitative measurements by using a constant amount of a graded kaolin diffused in a constant volume of water. The effect of various salts, &c., on jars filled with such a turbid medium were estimated by matching them against a standard series in which the flocculation was brought about by regularly increasing amounts of calcium nitrate. The authors show that the amount of material flocculated was proportional to the amount of flocculating salt added up to a certain point, above which any increase of salt produced no further effect; there was no adsorption of the salt, nor did flocculation involve any growth or permanent aggregation of the fine particles of the suspended matter. Conductivity measurements, while flocculation is going on, indicated that no perceptible change occurred in the amount of salts in solution. The acids were the most effective flocculators, and aluminium salts were almost equally effective. Calcium and barium were less than half as effective, magnesium came a little below calcium, potassium had only about one-fifth the value of calcium, and sodium only about half that of potassium, equivalent for equivalent. The nature of the acid radicle had an influence on the flocculating power of the salt, the order being hydrochloric, nitric, sulphuric, acetic (the chloroacetic acids had the same value as acetic acid itself); the same comparative order held for the salts as for the free acids. Oxalic and tartaric acids were feeble flocculators; citric acid, glycine, or

²⁷ *J. Landw.*, 1907, **55**, 233.

²⁸ *J. Agric. Sci.*, 1907, **2**, 221.

²⁹ *Ibid.*, 244.

phenol were without action. Soluble hydroxides such as caustic soda, potash, or ammonia opposed flocculation; calcium and barium hydroxides gave, however, positive effects, but much below those shown by their other salts, the flocculating effect of lime in practice being due to the formation of calcium bicarbonate, which is a very effective salt. Many substances, for example, bauxite and hydrated ferric oxide, do not form true suspensions in water, which property the authors regard as conditioned by the presence of double silicates, which hydrolyse and yield a little soluble alkali on contact with water. On this theory, flocculation is brought about by the neutralisation or throwing back into combination of the free alkali, although any final clearing up of the subject must be preceded by an explanation of the Brownian motion, which characterises particles in true suspension in a turbid liquid.

Chemistry of the Growing Plant.

1. *Nutrition.*—Although nothing very striking is to be reported in connexion with the nutrition of the plant, Fenton's synthesis of formaldehyde³⁰ from carbon dioxide by reduction of the aqueous solution with magnesium should be noted as the first reduction of carbon dioxide that has been accomplished at the ordinary temperature. This may be regarded as a step forward, although the synthesis is not of a type which can be imagined as taking place within a plant's cell; still, the evidence seems to be increasing that formaldehyde forms one of the steps in the natural process of photo-synthesis. G. Kimpflin³¹ detected formaldehyde in the leaf of *Agave* by injecting a solution of sodium hydrogen sulphite containing *p*-methylamino-*m*-cresol, which forms a red precipitate with formaldehyde, but not with other aldehydic compounds.

Although the function of the various mineral constituents of the plant is very far from settled as yet, a number of contributions to the subject have been made during the year. H. S. Reed³² has eliminated some of the difficulties inherent in the problem by working with algæ like *Spirogyra* in water cultures, from which the potash, the phosphoric acid, or other constituent in question could be omitted as desired. In this way, he observed that, in the absence of potash, all starch formation was suspended, and the granules originally present in the cells gradually disintegrated and disappeared. The lack of phosphoric acid proved very injurious, especially to the reproduction of the cells; there was no mitotic division of the nucleus, and there was an abnormal formation of cellulose.

³⁰ *Trans.*, 1907, **91**, 687.

³¹ *Abstr.*, 1907, ii, 289.

³² *Ann. of Botany*, 1907, **21**, 501.

In the absence of calcium salts, new cell walls were imperfectly formed, and the production of cellulose ceased, whilst magnesium appeared to be essential to the activity of the chloroplasts, since in its absence no oil globules were to be found, and the chlorophyll assumed a yellow colour. The latter observation is interesting in connexion with the important work by R. Willstätter³³ and his colleagues on chlorophyll and its derivatives, which they have shown to be compounds of magnesium, without any iron.

D. Lienau and A. Stutzer,³⁴ experimenting with oats, found that phosphoric acid promotes thickening of the cell walls, which, however, was diminished by potash and nitrogen. In consequence, phosphoric acid most promoted the stiffness of the straw. These results, as regards potash, are hardly in accord with former observations, or with the known function of potash to promote carbohydrate formation.

The long-debated question of whether the roots of plants secrete an acid, which aids in the nutrition of the plant by effecting the solution of the mineral constituents of the soil, has been the subject of further investigation. Kunze³⁵ reviews the evidence again, and concludes that only carbon dioxide is excreted. He does not, however, regard this as capable of bringing enough material into solution, and shows that the acid excretion from the mycelium of fungi in the soil is more effective.

Schreiner³⁶ brings evidence to show that the roots of seedlings both excrete acids and possess oxidising powers, but no argument as to plant roots generally can be drawn from the behaviour of the roots of autotrophic seedlings. Stoklasa and Ernest³⁷ also regard carbon dioxide as the effective natural solvent of minerals in the soil, and have been continuing their investigations on the amount that is excreted by plant roots and by micro-organisms in the soil. Under natural conditions, they obtain 15 milligrams of carbon dioxide in twenty-four hours from a kilogram of the soil they worked with.

Work continues to be reported on that much-debated question, the stimulus to plant production brought about by minute traces of metallic salts and other substances which in higher concentrations act as poisons. Despite the numerous investigations on the subject, for example, by Raulin, by Loew and his pupils in Japan,³⁸ by J. A. Voelcker in this country,³⁹ the prime fact of stimulus by minute traces of poison cannot be regarded as established. Increased growth has, doubtless, been observed to follow the applica-

³³ *Abstr.*, 1907, i, 69, 71, 784.

³⁵ *Jahrb. für. Wiss. Bot.*, 1906, 357.

³⁷ *Zeitsch. Zuckerind. Böhm.*, 1907, 31, 291.

³⁹ *Ibid.*

³⁴ *Ibid.*, ii, 47.

³⁶ *Abstr.*, 1907, ii, 715.

³⁸ *Ann. Report*, 1906, 257.

tion of such substances to the soil, but, as may be seen from the effects of antiseptics, previously reported, the soil is excessively complex and its equilibrium is easily disturbed. Hence it is by no means safe to conclude that any increased growth following the application of a manganese salt, for example, is due to the stimulus of the manganese to the plant. Kayser and Marchand⁴⁰ have studied the effect of small additions of manganese salts to alcoholic fermentations. They find that the start of the fermentation is sometimes checked by the presence of manganese, but that eventually higher proportions of alcohol, glycerol, and acids are produced from a given weight of sugar. Yeasts that have been habituated to comparatively strong solutions of manganese salts by growing in solutions of gradually increasing strength become particularly active, and will both induce a more rapid fermentation and push it further, especially if a small quantity of manganese salt is present in the fermenting liquid. Bertrand⁴¹ applied manganese sulphate at the rate of 50 kilos. per hectare to land on which wheat was sown, and obtained an increase in the total crop of 22.5 per cent., the corn being raised 17.4 per cent., and the straw 26 per cent. Here, again, there is no means of deciding whether the application of any other soluble sulphate might not have been equally effective by bringing into solution some of the dormant bases of the soil. G. Salomone⁴² and S. Uchiyama⁴³ report very similar results, in which even manganese dioxide exerted a beneficial influence on crops in the open field. A. Amos⁴⁴ attacked the problem from a different point of view. Various preparations of copper (of which the most widely used is Bordeaux mixture, prepared by precipitating copper sulphate solution with lime⁴⁵) are sprayed on the leaves and act as fungicides, but they are also credited with bringing about a longer life of the leaf, and an increase of crop, when no fungoid disease attacks the plants. Flowers of sulphur are dusted on to leaves for the same purpose. To ascertain if these substances acted as stimulants to the processes carried on by the leaf, Amos compared the rates of assimilation of two leaves upon the same plant before and after one of them had been treated with the fungicide, using Brown and Escombe's apparatus for the measurement of the rate of assimilation. The only result of the treatment with the fungicide was such a falling off in the rate of assimilation as might be expected from the inevitable blocking of the stomata, nor was any indication obtained that the activity of the leaf was

⁴⁰ *Abstr.*, 1907, ii, 288, 383, 903.

⁴¹ *J. d'Agric. Pratique*, 1906, 42.

⁴² *Abstr.*, 1907, ii, 982; also W. van Dam, *ibid.*, 649.

⁴³ *Bull. Cent. Exp. Sta. Japan*, 1907, 1, 37.

⁴⁴ *J. Agric. Sci.*, 1907, 2, 257.

⁴⁵ Pickering, *Trans.*, 1907, 91, 1988.

maintained to a greater age as a consequence of the treatment. The experiments were made with the leaves of the vine, and hop, and the artichoke (*Helianthus tuberosus*), for which plants values of the rate of assimilation had not previously been obtained.

2. *Plant Constituents and Changes of Composition during Growth*.—During the year, T. B. Wood has made an important step towards the resolution of a problem, the cause of "strength" in wheat flour, which has long occupied the attention of agricultural chemists in all countries. The question was the subject of a full debate at one of the meetings of the Chemistry Section of the British Association, and Wood's papers are published in the *Journal of Agricultural Science*.⁴⁶ Wood considers that strength, defined as the capacity of making large, well-piled loaves, is the outcome of two factors, one determining the size, and the other the shape of the loaf. The size is determined by the amount of carbon dioxide evolved in the dough, and this depends on the amount of sugar contained in the flour, together with that produced by diastatic action while the dough is rising. The shape of the loaf is determined by the consistency of the gluten, which does not depend on its composition, but on the salt content and acidity of the medium with which it is in equilibrium. Wood found that the gliadin and glutenin, of which gluten is made up, possessed the same composition (as far as might be judged from the products of hydrolysis), whether they were derived from strong or weak flours. By suspending pieces of washed gluten in a series of solutions in which both the acidity and the salt content varied by regular increments, Wood observed that for certain concentrations the gluten was tough and stable, while for others it disintegrated and lost all coherence. When the observations were all plotted with the salt concentrations as ordinates and acid concentrations as abscissæ, a closed curve could be drawn, all points within which represented solutions in equilibrium with the non-coherent gluten. Gluten, however, in contact with solutions represented by points outside the curve remained tough and elastic. Wood has discovered various relationships between the effect of different acids and salts known or likely to occur in flour, but the precise application of the facts to the discrimination of strong from weak flours remains to be worked out, a method for doing which is indicated. Little is known as yet of the nature or amount of the acids and salts present in an aqueous extract of flour, but these experiments show that they must exert a marked effect on the consistency of the gluten, so that in their variations a clue may be found to the abnormal behaviour of many flours. Wood also shows

⁴⁶ *J. Agric. Soc.*, 1907, 2, 139, 267.

that the consistency of other proteins, for example, the curd of milk, is similarly determined by the acidity and salt content of the solution with which it is in contact, and suggests that in this fact we have a general clue to the control of all such technical processes depending upon the physical properties of colloids.

Thatcher and Watkins⁴⁷ have studied the distribution of nitrogen in the different grains from the same ear of wheat, and again in different ears of the same variety. Their work goes to show that the variations thus found among the different ears of the same variety and between the grains of the same ear are due to nutrition, and are not hereditary. This result adds another to the arguments against the possibility of improving plants like wheat by "selection" alone.

Several facts of considerable chemical interest in connexion with the membranes forming the coats of seeds have been published during the year. In the first place, A. J. Brown⁴⁸ has shown that the barley grain possesses a true semipermeable membrane, through which water will pass freely, but not any of the salts which may be dissolved in the water. If, for example, unbroken barley grain is immersed in normal (4.9 per cent.) sulphuric acid, water only passed through the membrane into the endosperm, until the sulphuric acid solution outside became concentrated up to 7.6 per cent. The grain also absorbed water from 18 per cent. sulphuric acid, but failed to do so from a solution containing 36 per cent. of acid. The effective membrane appeared to be located in the spermoderm, since this layer resisted the action of 36 per cent. sulphuric acid, by which the outer layer of cells forming the pericarp was disintegrated. Iodine was the only dissolved substance that was found capable of passing through the membrane, and it seems significant that the substance so doing should also be one combining with the starch of the endosperm.

C. Bergtheil and D. L. Day⁴⁹ showed that the irregular and slow germination of the seeds of Java Indigo (*Indigofera arrecta*) was due to the preponderance of "hard" seeds, formed only when the seed crop was allowed to become thoroughly ripe. These hard seeds are practically impermeable to water, owing to a thin outer covering, neither true cellulose nor true cuticle, which can be removed by scratching or by steeping the seed for half an hour in concentrated sulphuric acid, followed by immersion in water.

Similar "hard" seeds in clovers and other European leguminous plants have been studied by Hiltner and Kinzel,⁵⁰ who recommend

⁴⁷ *Abstr.*, 1907, ii, 983.

⁴⁸ *Ann. of Botany*, 1907, **21**, 79.

⁴⁹ *Ibid.*, 57.

⁵⁰ *Zeitsch. für Landw. u. Forst. Wirts.*, 1906, 36.

treatment of the seed with hot water or sulphuric acid in order to promote germination.

Amongst other papers dealing with plant constituents, one should be noticed by E. Schulze,⁵¹ in which he maintains that the darkening of beet and other plant juices is not due to the enzymic oxidation of tyrosine, as is commonly supposed. The tyrosine he could obtain from the juice of beet, potato, and dahlia tubers was too small in amount to account for the darkening; moreover, after darkening, the tyrosine was still there, and no trace of homogenetic acid could be detected.

In the chemistry of enzyme actions, we owe to F. Ehrlich⁵² the interesting observation that fusel oil in alcoholic fermentation is derived from leucine. The leucine is split up by the enzymes, and the nitrogen-containing groups are used for the formation of proteins in the yeast cells. Ordinary leucine yields inactive amyl alcohol; *isoleucine* gives *l*-amyl alcohol.

Manures and Manuring.

As regards fertilisers, the year has nothing new to show; both field and pot experiments continue to be made with the two new products containing nitrogen derived from the atmosphere, crude calcium nitrate and calcium cyanamide,⁵³ and agree with previous trials to show that the nitrogen of both substances is in a highly available condition. But neither product is yet on the market on any large scale, although the small factory at Notodden is continually turning out calcium nitrate, and the Italian Cyanamide Co. at Piano d'Orta are rapidly increasing their output. It is understood that very large works are being erected for both processes, so that next season may see these fertilisers on the ordinary market.

Meantime, the two substances with which the new fertilisers will mainly enter into competition, ammonium sulphate and sodium nitrate, continue to receive considerable attention; there has been quite a revival of investigations into the relative value and actions on different soils of these two old-standing manures,⁵⁴ although it cannot be said that any new point of view has been disclosed.

Turning from the most recent to the oldest of fertilisers, farm-yard manure, Schneidewind,⁵⁵ at Lauchstadt, has been continuing the very interesting series of researches begun by Maercker on the

⁵¹ *Abstr.*, 1907, ii, 293.

⁵² *Ibid.*, 383.

⁵³ *Ibid.*, 48, 295, 573, 646, 807.

⁵⁴ H. Süchting, *ibid.*, 646; Schneidewind, *Landw. Jahr.*, 1907, **36**, 598; Kretschmer, &c., *Abstr.*, 1907, ii, 809.

⁵⁵ *Landw. Jahr.*, 1906, **36**, 569.

losses of nitrogen that are experienced in making dung and the best methods of conservation that can be adopted in practice. These investigations have the great advantage of being made on a large scale and under working conditions, and are not open to the objections which attach to most of the laboratory experiments that have been reported on materials for conserving dung. Schneidewind pronounces against gypsum and other materials of like nature; not only are uneconomical quantities necessary to be effective in saving nitrogen, but the calcium sulphate becomes reduced to sulphide, which afterwards acts injuriously in the soil. Instead, he confirmed his former observation that the greatest saving of nitrogen is effected if the base of each new dung-heap is made of a layer from an old fermenting heap. Schneidewind has hardly arrived at an explanation, but he thinks the difference may be brought about by the carbon dioxide evolved from the initial layer; of the experimental fact he has no longer any doubt.

The losses of nitrogen in making farmyard manure have also been studied by T. B. Wood⁵⁶ in the course of a feeding experiment, in which four heifers received known weights of food, which was analysed from time to time. The dung was not disturbed, but was analysed by cutting out sections at the end of the feeding period, and again six months later. About 15 per cent. of the nitrogen in the food and litter was lost in making the dung, and on storage the loss increased to 28 per cent. for poor dung made from roots and hay only, and to 40 per cent. for the richer dung obtained by feeding also with cotton cake. Since the digestible nitrogen in such rich foods is excreted as urea, which readily ferments and undergoes loss, even under good management, it is not always possible to recover in the manure the half of the nitrogen contained in purchased foods, which is the basis now usually adopted for compensation to the outgoing tenant for the fertility he leaves behind on the farm through the feeding-stuffs he has bought and consumed during the last year of his tenancy.

Chemistry of Animal Nutrition.

A paper which is likely to have a considerable bearing on the theory of animal nutrition, since it throws light on the fact well known to practical graziers that the proteins of different foods have not the same values for putting on flesh, has been published by Miss Willcock and F. G. Hopkins.⁵⁷ They showed that when zein is the only nitrogenous food given to young mice, they soon die, but when tryptophan, which is absent from zein, is added, the survival of the animals is greatly prolonged, indicating that the

⁵⁶ *J. Agric. Sci.*, 1907, 2, 207.

⁵⁷ *Abstr.*, 1907, ii, 109.

tryptophan group is necessary in building up the proteins specific to mice, and that it cannot be replaced by similar amino-acids like tyrosine.

The view, now generally accepted, that in digestion the proteins are broken down very thoroughly into simple amino-acids and kindred bodies, which are put through a building-up process in the intestinal wall⁵⁸ before they reach the blood, has continued to receive much discussion. It is well illustrated in an investigation of Abderhalden and his colleagues,⁵⁹ who found that feeding a dog on gliadin (a protein very rich in glutamic acid) did not increase to any marked degree the amount of glutamic acid in the blood proteins. Bound up with this subject is the question of the utilisation by animals of the non-protein nitrogenous materials in feeding-stuffs. O. Kellner⁶⁰ maintained that they can, to a certain extent, replace proteins in the diet, because they become built up into proteins by bacteria in the intestine of herbivorous animals; M. Müller⁶¹ finds that soluble non-proteins from hay can be utilised in the formation of flesh of a dog, whilst K. Friedländer⁶² found that the non-proteins of molasses fed in conjunction with food deficient in nitrogen were unable to prevent loss of nitrogen in the animal, although most of the nitrogenous compounds in the molasses could be converted by bacteria into proteins.

The parallel question of how far animal fat in the body or in the milk is reconstructed from the fat in the food is discussed in a paper by von Knierim and Buschmann.⁶³ Feeding milch cows with various oil-cakes, they found that both the milk yield and the composition of the butter fat, as measured by its physical properties, were affected by the feeding in a way which could only be explained by assuming that some of the fat of the food had passed into the milk unchanged. How far the fat had been broken down in digestion and then built up again was not discovered.

Analytical.

The determination of phosphoric acid continues to attract a good deal of attention; in most countries, the accepted method is to precipitate as phosphomolybdate, which is dissolved in ammonia, the phosphoric acid being reprecipitated with magnesia mixture. Since it is a lengthy and comparatively expensive process, many alternatives have been suggested, and two long and critical papers have appeared in 1907 by Mach⁶⁴ and Wagner, Kunze, and Simmer-

⁵⁸ *Abstr.*, 1907, ii, 893.

⁵⁹ *Ibid.*, 487.

⁶⁰ *Ibid.*, 491, 794.

⁶¹ *Ibid.*, 645.

⁶² *Ibid.*, 895.

⁶³ *Landw. Jahr.*, 1907, **36**, 185.

⁶⁴ *Abstr.*, 1907, ii, 395.

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macher,⁶⁵ showing that equally accurate results can be obtained by direct precipitation with magnesia mixture in the presence of citric acid, if the silica be first removed. A critical paper on the estimation of potash as perchlorate, as applied to agricultural analyses, has been published by Schenke and Krüger,⁶⁶ who show that sulphuric, phosphoric, and hydrochloric acids must first be removed.

A. D. HALL.

⁶⁵ *Abstr.*, 1907, ii, 577.

⁶⁶ *Ibid.*, 910.