DEPARTMENT OF AGRICULTURE,
NEW SOUTH WALES.

*SCIENCE BULLETIN,
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THE RELATION OF FERTILISERS TO SOIL FERTILITY.

By

F. B. GUTHRIE.

Workers in the respective branches of Economic Science covered by this series of Science Bulletins will receive such of them as may be of use in their special branches of study upon application to the Under Secretary, Department of Agriculture, Sydney.

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The Relation of Fertilisers to Soil Fertility.*

A SHORT SURVEY OF PRESENT VIEWS ON THE SUBJECT.

F. B. GUTHRIE, Chemist.

IN looking through previous volumes of the Association I find that the addresses of my predecessors in the office to which you have done me the honour to elect me, have dealt, without exception, with the broader aspects of the connection of the State, or of this Association, with agricultural progress or agricultural education.

It seemed, therefore, more fitting that I should take as the subject-matter of my address the development of some specific branch of agricultural science, especially as nearly everything I could say on the subject of agricultural policy has been well said by my predecessors. An occasion like the present appears a suitable one in which to pass in review the most recent advances made in our science, as the presence of so many workers from the different States renders it possible to discuss new developments from various points of view.

A great deal of what I shall have to say—probably all of it—will not be new to those of you who are engaged in scientific work in agriculture, and have followed recent developments at all closely; but there are, no doubt, many who have not the time nor opportunity to keep themselves posted in the literature of the subject, to whom I trust a presentment of the matter may prove of some interest.

To all alike a review of what has been done in any given line of work should stimulate discussion and be an incentive to further investigation.

I purpose to review shortly the main lines along which recent work has been conducted regarding the relation of fertilisers to soil fertility.

The trend of recent research in agricultural science has brought forcibly home to us the fact that the function of fertilisers is not restricted to the duty of supplying plant-food to the growing crop. Under certain circumstances, indeed, this function is in abeyance—in the absence of sufficient water, for example, or in the presence of unfavourable soil-conditions, the action of fertilisers is almost negligible—and it is our lack of understanding of these conditions that has been the frequent cause of want of success in the use of manures.

The idea that failure in plant-production is due solely, or even chiefly, to deficient plant-food in the soil is no longer tenable.

* Presidential address delivered before the Agricultural Section of the Australasian Association for the Advancement of Science, Melbourne, January, 1913.

Recent investigations have brought to light a host of other causes of infertility, but the idea still persists at the back of many soil analyses, that the determination of the amount of certain specified plant-foods, dissolved by specific solvents from the soil, is a certain guide to the nature of the manuring required. As a matter of fact, neither the chemical composition of the soil nor of the crop affords any certain foundation on which advice as to manuring can be based.

A. D. Hall and E. J. Russell,* dealing with the results of a soil survey of the south-eastern counties of England, draw, amongst other general conclusions, the following which have special reference to the connection between the composition of the soil and plant: "We are not as yet in a position to deduce the agricultural properties of a soil, either its behaviour under cultivation or its adaptability to particular crops, except in the roughest general fashion."

In dealing with a number of typical wheat-soils the authors say, "chemical analysis of these soils revealed no connection between their chemical composition and their suitability for wheats," and the same remark applies no doubt to other crops. They also point out that excess or deficiency of any particular plant-food, such as nitrogen, does not necessarily imply a fertile or infertile soil.

Even in the case of calcium carbonate, they show that many soils poorly supplied with this ingredient are not benefited by the application of lime, whereas for other soils examined, containing the same or a greater proportion, liming is essential.

They find that, "other things being equal, dry soils are more likely to respond to potassic manuring than others better supplied with water, but no richer in available potash."

The same applies to phosphoric acid. "Little, if any, direct connection can be traced between the phosphoric acid and the productiveness."

As far as regards the value of soil-analysis, as a basis on which to afford advice as to soil treatment, I have no reason to alter the opinion expressed in a paper on "Soil Analysis," read before this Association at the Brisbane meeting, 1895, wherein the view is expressed that a rational scheme of soil-analysis which shall attempt rather to determine the factors influencing fertility than to elaborate methods for determining the chemical constitution of the soil, can be made of considerable value to the farmer. This statement has been amply borne out by experience, and to-day the analysis of farmers soils on the lines then laid down is one of the functions of the Department most regularly availed of by farmers.

In spite of all the labour expended for many years on this subject, manuring still remains very largely empirical in its nature. We know, in a broad and general way, that a soil deficient in plant-food is not likely to produce good crops without manuring, and that a soil rich in plant-food is likely to prove a fertile one. But much further than this we cannot go. If a soil is well supplied with, say, nitrogen and potash, but poor in phosphates, it by no means follows with any certainty that it will be benefited by phosphatic manuring.

* *Journ. Agric. Science*, vol. 4, p. 182.

We know further that certain fertilisers benefit certain crops. We know, for example, that the application of superphosphate will probably increase the yield of wheat and other cereals; but this knowledge is not derived from information supplied by the composition either of the soil or the wheat plant.

The wheat crop, grain and straw, contains only half the quantity of phosphoric acid that it does of nitrogen, and much less than it does of potash, and yet we know that neither nitrogenous nor potash manures are anything like as effective as soluble phosphates in increasing the yield. Nor does soil-analysis help us to any extent. The soil may be comparatively rich in phosphates and poor in nitrogen and potash, and still phosphatic manuring is the more effective. Our wheat soils in the semi-dry country are indeed lacking for the most part in humus and nitrogen, and yet it is by the application of superphosphates and not of nitrogenous manures that crops are successfully grown.

The case of leguminous plants is of a similar nature; crops like peas and beans and clover contain more nitrogen than other fertilising ingredients, and yet manuring with nitrogen is resultless, and the ingredients which are most beneficial are potash and phosphates. Here again, it is immaterial whether the soil is rich or poor in nitrogen or rich in potash. The composition of fruit-trees does not explain why potash manuring should be of such special benefit, nor is there any satisfactory explanation why the mangel crop—which contains nearly four times as much potash as the potato crop—should not benefit by the application of this ingredient, whereas it is an essential, a "dominant" ingredient for manures applied to potatoes.

I do not wish to press this point further, but simply to accentuate my statement that the composition either of the crop or of the soil is not an infallible guide to the nature of the manuring required. In fact, we have not advanced much on the principles enunciated by Ville. We still manure with a complete manure, paying special attention to the ingredient which is "dominant" for the particular crop.

Explanations of these peculiarities will no doubt be forthcoming. In the case of leguminous crops, we are acquainted with the process by which they obtain the required nitrogen from the air and are independent of soil nitrates or nitrogenous manuring.

In the case of wheat, I have suggested an explanation, which I venture to think is the correct one, of the rather extraordinary phenomenon that the application of nitrate or other nitrogenous manure which is essential to the production of wheat in Europe and America is without effect on crops grown locally, its place being taken by superphosphate.*

Shortly stated, this explanation lies in the different conditions as to nitrification prevailing here and in Europe and America during the growth of the crop. In the latter countries the wheat commences to grow in soil from which the nitrates have been washed out, and in which nitrification does not take

* *Agricultural Gazette*, New South Wales, vol. xvii., p. 29.

place until the crop is approaching maturity. With us nitrification is active and progressive during the early growth of the wheat plant, and nitrogenous manuring is unnecessary, all that is required being the application of a fertiliser which promotes the development of the root-system, a quality which appears to be possessed in a high degree by superphosphate, thus ensuring the young plants a vigorous start.

It has been further shown by J. W. Paterson and P. R. Scott* that superphosphate appreciably increases the nitrification of ammonia, indicating that, in some cases, the addition of phosphates may help to nourish the nitrifying organisms as well as the crop.

We will now review shortly some of the recent work which has shown that the growth of plants is affected by causes other than lack of plant-food, or unfavourable mechanical soil conditions, and which encourages us to look to other remedies for unfertile conditions.

We shall see, incidentally, that fertilisers may have an action upon the growth of the plant which is altogether independent of its power of supplying plant-food, and which until recent years has been quite overlooked.

Toxic Substances in Soils.

That substances are formed in the soil, either as the result of the decomposition (chemically, or by means of micro-organisms) of crop-residues, or excreted by the growing plant, seems to be abundantly proved.†

O. Schreiner was the first to show the toxic effect of dihydroxystearic acid and to isolate this substance from soils on which wheat failed to grow.‡

Further experiments by the United States Bureau of Soils§ have shown that quite a large number of organic substances exercise a toxic action on plant growth.

F. Fletcher‖ describes experiments showing the extraordinary influence of the neighbourhood of sorghum and of maize upon the growth of "sesamum indicum." This is not due to the removal of moisture or of plant-food by the maize crop, as both these essentials were abundantly supplied to the sesamum, but must, he concludes, be attributed to the excretion of a toxin by the roots of the maize plants. Fletcher believes this to be a salt of dihydroxystearic acid.

Among the numerous toxic organic compounds which Schreiner and his fellow-workers have found to be present in the soil, three or four have been more particularly studied in relation to their action upon plants provided with varying quantities of the recognised fertilising ingredients.

Schreiner and Skinner¶ have shown that in water cultures with wheat, dihydroxystearic acid is least harmful when the plant is provided with fertilising substances relatively rich in nitrogen (such as nitrates), and that in

* *Journal of the Department of Agriculture*, Victoria, vol. 10, p. 393.
† Schreiner and Shorey, Bull. 74, Bureau of Soils, U.S.A.
‡ Bull. 53, Bureau of Soils, U.S.A.
§ Schreiner and Reed, Bull. 47, Bureau of Soils, U.S.A.
‖ *Journ. Agric. Science*, IV, p. 245.
¶ Bull. 70, U.S.A. Bureau of Soils.

the presence of this soil toxin the plant removed less phosphoric acid and potash than under normal conditions, but that its absorption of nitrogen was more nearly normal.

The action of other soil toxins was made the subject of further study* and the following very interesting and rather remarkable results were obtained:—Vanillin (an aldehyde) behaves in very much the same way as dihydroxystearic acid in its general effect upon roots and leaves, and its effects are least when the plant is supplied with nitrates. It is pointed out that nitrates increase root-oxidation, whereas both dihydroxystearic acid and vanillin, being capable of further oxidation, are themselves reducing agents.

Quinone is another organic substance whose presence affects the growth of plants. Unlike the two substances mentioned above, quinone is an oxidising agent, and its ill-effects are less marked when the plant is supplied with relatively large proportions of sulphate of potash, which has a known influence in restraining root-oxidation.

A fourth substance is coumarin, a substance of fairly wide distribution in the vegetable kingdom, and found to be toxic to many plants. Schreiner and Skinner† find that it is particularly toxic to wheat, the leaves being short and broad, and the roots discoloured, and their surface very shiny. The harmful effect of this substance was greatest when phosphoric acid was absent from the nutrient solution, and practically disappeared when the fertiliser was rich in phosphates. The same results were obtained with wheat-plants grown in soil in culture-pots.

It would, therefore, appear that the bad effects due to the presence of dihydroxystearic acid and of vanillin can be to a large extent neutralised by the application of sodium nitrate, those due to coumarin by phosphoric acid, and those due to quinone by sulphate of potash. With the exception of coumarin, these experiments were carried out apparently only in water-culture experiments, and the point must not be lost sight of that these results when tried in the field may be considerably modified by the chemical or physical nature of the soil. They are sufficiently striking to emphasise the fact that the function of fertilisers is not solely to supply plant-food.

Fungi Affecting Crops.

Another way in which one crop may affect injuriously a succeeding crop is by the production of a fungus which infects the soil and attacks the young plants. A fungus of this nature has been found by H. L. Bolley‡ to be the cause of what are known as flax-sick soils, that is soils which after continuous cropping with flax (which does not unduly exhaust the soil) are unable to produce flax. He quotes an experiment in which flax was grown for six consecutive years on a fertile soil of the Red River, the result being that the land was "in such a diseased condition that not a plant of flax can exist on it longer than three weeks from the time of sowing." This

* Schreiner and Skinner, Bull. 77, U.S.A. Bureau of Soils.
† *Loc. cit.*
‡ Bull. 50, North Dakota Agric. College, 1901.

condition of things is well known in Europe and America to flax-growers, and it is the custom in Europe at all events to sow flax at intervals of not less than eight years on the same land, the flax being part of a rotation including turnips, oats, clover, wheat, and beans.

Bolley has found that this flax-sickness is due to the growth of a fungus which he calls *Fusarium lini*, which lives in the humus of the soil and attacks the flax-plant.

Manuring of any description was quite ineffective in improving the growth of flax or in destroying the fungus, nor did treatment of the soil with any of the usual fungicides produce any better results. There appears to be no way to rid the soil of the parasite, as the fungus lives in the soil for many years without any flax crop to feed upon. This fungus does not appear to attack any other crop.

The remedies suggested are treatment of the seed with substances such as formalin, and a five years' rotation of flax with wheat, hay, pasture, and maize.

Bolley has also shown* that the deterioration of wheat-lands is brought about by three or four parasitic fungi (in a later communication he gives the number as at least five), whose growth is encouraged by the practice of continuous cropping of the land with wheat, and which are propagated and attack the wheat plant in exactly the same way as flax is attacked by *Fusarium lini*.

Similar instances of loss of crop-producing power have been long familiar, that of clover sickness being one of the earliest to be recognised. Peas, beans, turnips, and cauliflowers are all subject to parasitic fungi which grow on the buried portions of diseased plants and communicate the disease to healthy plants. The same is also true of many of the fungus diseases which affect the potato, tomato, &c.

Infertility often due to Bad Husbandry.

In all these cases we have toxic conditions which are quite distinct from the infertile condition brought about by soil-exhaustion, conditions which are not dependent upon the richness or poverty of the soil, and which no amount of manuring in the ordinary sense will remedy. Indeed, when we consider the large stores of plant-food in average and even in poor soils, the comparatively small proportion removed by even the most exhausting crop, and the fact that this store of plant-food is being constantly rendered available, it becomes difficult to realise that a few years' cropping can effect such a complete removal of plant-food, as we must assume to take place if the soil is exhausted in the manner usually recognised.

As a matter of fact, analyses of European soils go to show that under continuous cultivation there is little or no difference in the mineral content of the soil. In short, the inferior crop-producing power of a soil after repeated cropping is due to other and more obscure causes than the simple depletion of the soil in plant-food.

* Press Bulletin No. 33, North Dakota Agric. Expt. Station, Oct. 1909.

It is open to doubt whether such a thing exists as an infertile soil, that is, one which will not give satisfactory results under proper treatment. Plants, we know, can be grown in ignited sand or distilled water, if the proper nourishment is supplied. The barren regions of the earth are all capable of being made reproductive under proper treatment, witness the alkali-lands of Texas, and the salt-lands of Utah. Even the desert yields abundantly in the fortunate places where springs occur, or where the land can be inundated by rivers. On the other hand misapplied energy may convert a fruitful country into an unproductive one, and much of the desert and sterile land has once been fertile, and has been brought to its present condition by unthrifty husbandry.

Travellers in Palestine tell us that its numberless hills are covered with the ruins of what have once been populous cities, a certain sign that the surrounding country has once been, not only fertile, but extensively cultivated to provide food for the town populations.

Sir Frederick Treves, the most recent visitor to record his impressions of this country in his work "The Land which is Desolate," contrasts the promised land "that floweth with milk and honey" with the "poverty stricken, miserly, thread-bare country" of to-day.

The plain on which the ruins of Babylon now stand is still covered with a network of old canals, which served both to irrigate and to drain what was in ancient days extremely fertile country, but which is now divided between desert and marshes. Herodotus testifies to the remarkable fertility of Babylon in his time, when it was a great commercial centre.

Professor Heeren in his work on the "Commerce, &c., of the Principal Nations of Antiquity," tells us how the discovery of a new path to India across the ocean, converted the great commerce of the world from a land-trade to a sea-trade, and thus Nineveh "sunk to its original state of a stinking morass and a barren steppe."

This is that same Nineveh, the capital of a country which its king described as "a land of corn and wine; a land of bread and vineyards; a land of oil-olive, and of honey."

There are many other instances where great and populous centres have flourished at the expense of the surrounding country, which they have finally impoverished and involved in their own ruin, and this is a danger, probably the greatest danger, with which rural Australia is faced to-day.

Plant Secretions not always Toxic.

The secretions of plants are not, however, necessarily always toxic to other plants. The beneficial results of growing leguminous plants with non-legumes is well known, and an experiment carried out by J. G. Lipman shows this particularly well.*

Lipman grew oats in quartz-sand in porous pots which were placed in larger pots also filled with quartz-sand in which field-peas were grown. The

* *Journ. Agric. Science*, vol. 3, p. 297.

sand in both cases was supplied with the necessary mineral fertilising constituents, but with no nitrogen. Both plants grew vigorously, the oats obtaining their supply of nitrogen by the diffusion of soluble nitrogenous material from the outer pot in which the legumes were growing.

If, instead of a porous inner pot, the oats were grown in glazed pots and were thus unaffected by the nitrates formed by the legumes, they produced a much diminished yield, and showed the growth and colour associated with lack of nitrogen.

Another case in which a beneficial action is exerted on the growth of plants by organic soil-constituents, and one in which such action cannot be attributed to any direct fertilising power, is furnished by creatinine and creatine. Creatinine is an organic substance which exists not only in the humus of soil, but in farmyard and organic manures, and in many plants and seeds, and whose presence in the soil has been found to indicate fertility.

The United States Soil-Bureau * have isolated and experimented with this substance, and with creatine, of which latter it is the anhydride. These authors have found it in stable manure and peas used as green manures; also in wheat, seedling wheat grain, bran, rye, some leguminous plants, and potatoes.

Both creatine and creatinine are nitrogenous substances, and experiments in manuring show that they can replace nitrate in its effects on plant-growth, at all events in culture solutions.

Micro-organisms—Toxic and beneficial.

In yet another direction a great deal of interesting work has been done, showing the part played by minute organisms in relation to soil fertility. It had been known for some time that treatment of the soil both by heat and by antiseptics favoured the growth of crops.

S. U. Pickering † found that when soils were either heated or treated with antiseptics the total soluble organic matter of the soil was increased, and at the same time toxic conditions were produced which hindered germination, such inhibitory action being, however, only temporary, as the toxins were subsequently destroyed, presumably by oxidation.

E. J. Russell and H. B. Hutchinson, ‡ in an elaborate and careful series of experiments, appear to have shown conclusively that the beneficial effect of partial sterilisation by heat or antiseptics upon the growth of the crop, is attributable to the larger proportion of ammonia present in the soil after such treatment. These authors explain this phenomenon as follows:—Probably in all soils certain larger unicellular organisms (protozoa) are present, which feed on the bacteria concerned in the formation of soluble nitrogen compounds and keep them in check. If the soil is partially sterilised by heating for a short time to the temperature of boiling water, or by subjecting it to the action of vapours such as chloroform, bisulphide of

* Schreiner, Shorey, Sullivan, and Skinner, Bull. 83, Bureau of Soils, U.S.A.
† *Journ. Agric. Science*, vol. 3, pp. 32 and 258.
‡ *Journ. Agric. Science*, vol. 3, p. 111.

carbon, toluene, &c. (such vapour being subsequently removed by spreading the soil out in a thin layer and allowing the vapour to evaporate), the effect is to destroy the protozoa and probably most of the bacteria as well, but not the spores of the ammonia-producing bacteria. These spores subsequently develop, and in the absence of the hostile protozoa, their development proceeds with increased activity, the result being a considerable increase in the soluble nitrogenous plant-food and a more vigorous crop growth.

These experiments have so far been carried out in the laboratory. If means are discovered of partially sterilising the soil in the field, a most valuable method of increasing the fertility of the soil will be placed at the disposal of the farmer.

Indeed, experiments in this direction have been recently carried out by E. J. Russell and J. Golding* on "sewage-sick" soils. They find that "sewage-sickness" is an abnormal development of the factor harmful to bacteria (protozoa) always present in ordinary soils, and that the loss of efficiency in the purification of sewage in such soils is due to the hindrance of the development of the bacteria. Small land-filters were made in the field, some being filled with untreated soil and others with treated or sterilised soil. The effluents were examined periodically. The untreated samples soon became "sewage-sick," whereas the effluents from the treated filters retained their efficiency for months. A further experiment was tried by treating small plots in a similar manner, the plots being then sown with turnips. The crops on the treated plots (especially that treated with toluene) were not only better than those from the untreated, but suffered much less from "finger and toe."

Further interesting trials were recorded by E. J. Russell and F. R. Petherbridge† of the action of heat and antiseptics upon sickness in glass-house soils. In countries where plants like cucumbers and tomatoes are grown under glass, the soil is found to be unsuitable for the growth of these plants after a short time, sometimes after the first crop. The soil used is therefore thrown away, and as it is necessary to enrich it very much with manure and to expend much time and labour on its preparation, this is a very wasteful operation. The authors find that previous steaming of the sick-soil of a commercial glass-house in which cucumbers were grown, resulted in curing the soil of cucumber-sickness and rendering it once more commercially profitable. The same was found to be the case with tomato-sick soil on which a number of different antiseptics were tried. Of all methods, heating the soil to 98° was found to be the most effective. The cost of this operation is from 1s. to 1s. 6d. per ton of soil, which while profitable in the case of plants grown under glass, is quite prohibitive on large areas.

S. U. Pickering‡ considers that on heating a soil the amount of soluble plant-food is increased, and the changed bacterial conditions studied by

* *Journ. Agric. Science*, vol. 5, p. 27.
† *Ibid.*, p. 86.
‡ *Journ. Agric. Science*, vol. 3, p. 277.

Russell and Hutchinson conduce to more vigorous growth, but that at the same time certain toxic substances are formed which arrest plant growth, but as these toxins are unstable and readily oxidised the toxic conditions do not prevail for any length of time.

F. Fletcher* obtained very much higher yields with maize plants grown in soil previously heated, which results he attributes to the destruction by heat of an alkaloid dihydroxystearate. He also finds germination injuriously affected by previous heating. This he attributes to increased osmotic activity which results in a decrease of imbibition, brought about by increase of soluble organic substances.

R. Greig-Smith,† to some extent opposes the conclusions of Russell and Hutchinson. The beneficial action of disinfectants, such as chloroform, toluene, &c., is explained by him as being due to the removal, by these reagents (all of which are wax-solvents), of a wax-like substance (agricere) with which the soil particles are coated. With the removal of this waterproofing the soil nutrients are more easily dissolved in the soil-water and attacked by bacteria.

According to this investigator, the principal nitrogen-fixing bacterium in soils is *Rhizobium leguminosarum*, the number of which affords an indication of the comparative fertility of the soil, and which, in the most fertile soils, may be present to the number of three or four millions per gramme of soil. He finds, further, that all soils contain a substance which acts as a bacteriotoxin, fertile soils containing a small, poor ones a large amount. This toxin is destroyed by heat, sunlight, and storage, and is washed into the subsoil by rain, so that after a shower of rain the surface soil is richer in bacteria than the lower strata. This latter is an extremely interesting observation, as indicating that the beneficial effects of rain or of irrigation are not confined to the mere supply of water or even of fertilising salts to the soil.

These bacterio-toxins are insoluble in wax-solvents, and are not volatile.

He finds also that after the protozoa have been destroyed by heat at 65° to 70°, the action of volatile disinfectants is to increase still further the bacterial productiveness of the soil.

Additional indication that these disinfectants act as wax-solvents in dissolving the agricere, is afforded by the fact that the upper layers of soils so treated are less nutritive to bacteria than the lower, which is what might be expected if the disinfectant on evaporation carried the agricere to the surface.

Dr. Greig-Smith is reading a paper before this section, in which he recapitulates his work in this connection.

If the theory that the action of heat and of solvents is to destroy the waterproof coating is correct, one would expect that the soils so treated would yield more of their mineral ingredients to soil-solvents. The evidence

* *Cairo Scient. Journ.*, 1910, 4, reprint (Abstract in *Chem. Soc. Journ. Abstracts* vol. 100, ii, 350).

† *Proc. Linn. Soc.*, N.S.W., vol. 35, p. 808; vol. 36, pp. 492, 609, 679.

on this point is not conclusive, but it is fairly certain that the increases, when such have been found, are insufficient to account for the great increase in fertility noted by Russell and Hutchinson (three or four times the crop in the case of heat, and 20 to 50 per cent. in the case of volatile antiseptics).

S. U. Pickering* shows a slight increase in the total water-soluble material, both of heated and of treated soils, but the nature of the mineral matter extracted is not stated.

G. S. Fraps† has found that previous ignition increases the amount of phosphoric acid, which can be dissolved from several naturally occurring phosphates. Wavellite, in particular, yields ten times as much phosphoric acid, soluble in $\frac{N}{5}$-nitric acid, after as before ignition.

It is to be remembered, however, that in this case there is no question of the presence of agricere, and further, that, in our soils, at all events, these minerals are not likely to be present in any quantity.

C. B. Lipman‡ finds in the case of soils the opposite effect to that noted by Fraps in the case of phosphatic minerals. He finds that the effect of igniting soil is to reduce the amount of phosphoric acid extracted by nitric acid. This agrees with the observations of J. König and others§ that phosphoric acid is fixed by colloids in the soil forming insoluble calcium phosphate, so that the combination is rendered more complete by the action of heat.

H. I. Jensen|| has also investigated this point. He treated several soils of varying known degrees of fertility with different soil-solvents before and after ignition—*e.g.*, strong hydrochloric acid (sp. gr. 1·1), citric acid (1 per cent.) and nitric acid ($\frac{N}{5}$).

The results are very irregular and vary in different directions, being frequently identical, but they point to the conclusion that in the case of heated soil at all events the increased fertility is not due to the greater solubility of the recognised plant-foods. Any considerable differences occur only in cases where the quantities of plant-food are extremely small and are probably due to experimental errors.

C. B. Lipman¶ has carried out experiments in which previously sterilised soil was infected with filtered suspensions, so as to remove the protozoa. He finds no difference in the results when such filtered liquids are used and when unfiltered suspensions containing protozoa are employed, and is "unable to confirm the claims of Russell and Hutchinson as to the influence of protozoa in modifying the amount of work done by decay bacteria."

Another view of the action of heat upon soils has been more recently advanced by O. Schreiner and E. C. Lathrop** and E. C. Lathrop††. These authors find that heating the soil results in an increase in the water soluble constituents

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* *Journ. Agric. Sci.*, vol. 3, p. 32.
† *Journ. Ind. Eng. Chemistry*, vol. 3, p. 335.
‡ *Journ. Ind. Eng. Chem.*, vol. 4, p. 663.
§ *Land. Versuch. Stat.*, 1911, vol. 75, pp. 377–441.
|| *Proc. Roy. Soc.*, N.S.W., vol. 45, p. 169.
¶ New Jersey Agric. Expt. Station, Bull. 248.
** *Journ. Am. Chem. Soc.*, vol. 34, p. 1242.
†† *Ibid.*, p. 1260.

and in acidity, although ammonia and amines are formed. Heating the soil produces simultaneously both beneficial and harmful organic compounds. Amongst the beneficial are xanthine and hypoxanthine, guanine, cytosine and arginine, and among the harmful hydroxystearic acid. These substances, if already present in the soil, are increased by heat, and if not originally present are produced by the action of heat. The heated soil possesses at first a decreased fertility, owing to the production or increase of dihydroxystearic acid, but when this ingredient disappears, either through oxidation, cropping, addition of lime or nitrate, the fertility of the soil is increased. This explanation, it will be seen, opposes the conclusions of Russell and Hutchinson as far as the effect of heating is concerned, and attributes this effect to the alteration of the proteid matter of the humus, rather than to the action of micro-organisms.

There are thus several theories in the field to account for the action of heat and of antiseptics upon the soil. On the one hand, it is attributed in both cases to a partial sterilisation of the soil, as a result of which certain organisms are destroyed which are hostile to the ammonia-producing bacteria; on the other hand, the action of antiseptics may, it is suggested, be due to the removal of an impervious wax-like material surrounding the soil grains, the presence of which hinders their being attacked by soil-solvents; and in the case of heating a third suggestion is that at first both harmful and beneficial organic substances are produced, the harmful ones being readily oxidised.

Effects of Fertilisers on Physical Properties of Soil.

Soluble salts in small quantities exert an influence upon the physical properties of soils. Aikman* points out that the quantities of fertilising matter in farmyard manure are insufficient and in an unsuitable form for the growth of crops, and that the chief influence of such manure is on the structure of the soil. R. O. E. Davis† has studied this influence more particularly in the case of the apparent specific volume of the soil, rate of capillary action, and change in vapour pressure.

He finds that most fertilisers accelerate capillary movement, sulphate of potash and a mixture of sulphate of potash and phosphoric acid retard it. Soluble salts, whether acting as plant-food or not, may produce in the soil changes in structure which in turn influence plant growth. Their effect is most pronounced in soils containing a large amount of fine particles.

Influence of Fertilisers on Soil-moisture.

The action of soluble salts in affecting the moisture conditions of the soil is of great importance. Cameron and Gallagher‡ have shown that the physical nature of the soil changes with its moisture-content, and consider that for every soil there is an optimum moisture-content at which its physical condition is most favourable for plant growth.

* "Manures and Manuring," p. 273.
† Bull. 82, Bureau of Soils, U.S.A.
‡ Bull. 50, Bureau of Soils, U.S.A.

Of the various problems presented by a study of the physical nature of the soil, the one which is of the greatest importance is the question of the behaviour of water in the soil. This applies with special force to us in Australia, where the problem of conserving the soil-moisture is of even greater importance than that of manuring. The action of fertilisers, especially potash salts, in keeping the surface soil moist, is well known. The application of fertilisers has been found to have a very considerable effect upon the transpiration ratio of plants, enabling them to make a better use of the available moisture.

In fact J. W. Leather* in the course of an investigation into the water requirements of crops in India, finds that the transpiration ratio (that is the relation between the weight of water transpired by the crop and the weight of the dry crop) is always lower when suitable manures are employed, and concludes that "speaking generally the effect of suitable manure in enabling the plant to economise water is the most important factor which has been noticed in relation to transpiration."

It appears possible, however, from more recent researches of the same author† that the decrease in the transpiration ratio when suitable manures are added, is due rather to the more vigorous growth of the plant than to any specific action of the manure on the transpiration ratio.

Dr. Leather has, at all events, shown this to be the case with superphosphate, which when supplied to a soil known to have no need for phosphatic manuring did not lower the transpiration ratio.

This, however, is a case in which it is possible to confuse cause and effect. The soil in question was unusually rich in available phosphoric acid, containing more than three times as much as the richest of the other soils, and it is not impossible that the transpiration ratio was affected by the presence of soluble phosphoric acid in the soil.

J. W. Paterson‡ has published results of experiments to determine the transpiration ratio of oats, which are of interest in this connection, although the question of the effect of manuring does not enter into the investigation.

He finds the transpiration figure for this crop, grown in pots and partially shaded during the period of their growth, to be about 483, that is to say, 483 tons of water are transpired for every ton of dry crop produced.

He assumes that for plants of moderate development, grown in the open air in Victoria, this figure would be 700, as against 870 in India (Leather, *loc. cit.*); 522 in America (King); and 665 (Wollny) to 376 (Helleriegel) in Europe.

According to Leather a 13-bushel crop of wheat (about 1 ton grain and straw) will transpire 693 tons of water (or 6·8 inches of rain) per acre in India. Dr. Paterson states that local conditions indicate that about 600 tons of water (6 inches of rain) per acre would pass through a 13-bushel crop of wheat during its growth under Victorian conditions.

* "*Memoirs*," *Dept. Agric.*, *India*, Cheml. Series, vol. 1, No. 8, p. 170.
† "*Memoirs*," *Dept. Agric*, *India*, Cheml. Series, vol. 1, No. 10, p. 230.
‡ "*Jour. Dept. Agric.*, Victoria, vol. 10, p. 349.

This estimate is not, however, supported by experimental figures, and it is to be hoped that Dr. Paterson will be able to continue his investigations so as to include the determination of the transpiration ratio of an average wheat-crop grown in the open under ordinary conditions, since the question is one of the very first importance in wheat-growing in Australia, and in establishing the geographical limits within which wheat-growing can be successfully carried on with us.

The subject of soil physics is much too wide to come within the scope of an address like the present one, but I have been tempted to draw attention to the possible influence of fertilisers on the movement of soil-moisture, because of the very great importance of the study of moisture conditions to us in Australia. In this connection an interesting investigation has been carried out by Dr. Heber Green and G. A. Ampt* in which are given methods of determining the constants, specific pore space (the free space per unit volume of soil), permeability to water and air, and capillary coefficient. It would be of very great interest to determine the extent to which the addition of fertilisers or soluble salts affect these constants.

Influence of Fertilisers on Soil-oxidation.

Another direction in which fertilising substances can function in other ways than as plant-food is in the promotion of oxidation in soils.

M. X. Sullivan and Reid† have shown that the oxidising power of soils is increased by the presence of water up to the optimum, and by the common fertilising substances, also by salts of iron, manganese, lime, and magnesia, especially when simple organic hydroxyacids are present. They find that soil-oxidation is comparable with the same process in plants and animals, and that it is greater in surface than in subsoil, and greater in fertile than in barren soils.

O. Schreiner and H. S. Reed‡ showed that calcium salts, phosphates, and nitrates increase the oxidising power of plant roots, whilst potassium salts tend to retard it.

Catalytes, or Plant Stimulants.§

There are also a large number of compounds whose presence in minute quantities appear to have very often a quite remarkable effect upon plant growth. These substances cannot be regarded as fertilisers in the ordinary sense. Some of them are of rare occurrence in the soil, or occur only in minute quantities; many of them are distinctly injurious in any large quantity. We are quite in the dark as to their precise function, and the name "catalytic" has been given to them for want of a better.

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* *Journ. Agric. Science*, vol. 4, p. 1, and vol. 5, p. 1.

† *Journ. Ind. Eng. Chem.*, 1911, vol. 3, p. 25.

‡ Bulletin 56, Bureau of Soils, U.S.A., Dept. of Agric. *See also* Schreiner, Sullivan, and Reid, Bull. 73, Bureau of Soils, U.S.A., Dept. of Agric.

§ A bibliography has been kindly prepared by Mr. L. A. Musso, of the Department of Agriculture, New South Wales, which is printed as an appendix and which may be found useful to those who wish to look up the literature of the subject. An excellent *résumé* of the subject is also published by M. Cercelet, *Revue de Viticulture*, tome 38, No. 981, p. 381.

H. Ost found small quantities of fluorine to be always present in a number of healthy leaves which he examined.

Aso, Oscar Loew, Ampola, and others, show that small quantities of fluorine have a stimulating effect on many plants. Iodine has been shown also to stimulate the growth of plants when in small quantities. Oscar Loew and the Japanese chemists, who have done a great deal of work in experimenting with the foregoing elements, and with lithium, cæsium, and uranium, find that they stimulate the growth of a number of plants both in the field and in pots. Titanium has also been found to increase the yield of crops. C. E. Wait has found titanium in the ash of every plant which he has examined, and Annett states that the colour of the black cotton soil of India is due to the presence of a titaniferous mineral. I have found titanium to be present in soils of the black-soil plains in the north-west of New South Wales, but cannot assert that this is the cause of their colour, since other soils, from the same locality and derived from the same minerals, which are red or chocolate in colour, also contain titanium. The addition of flowers of sulphur has also been found to improve the yield of many crops. Copper is stated by some writers to increase plant growth when present in small quantities, but by others to be injurious. Boron appears to be very widely distributed in the plant world, and the proof of its presence as a natural constituent of grapes and of wines is of considerable economic interest. At the rate of ½ gramme per square metre it has been found by Agulhan to increase enormously the yield of wheat, maize, rape, and turnips.

The literature with regard to manganese, its occurrence in plants, and the action of minute quantities, is voluminous. In minute quantities it appears to be beneficial, in larger quantities toxic, and its toxicity appears to increase with its stage of oxidation.

Other substances that may be mentioned in this connection are vanadium, chromium, nickel, barium, zinc, mercury, didymium, and glucinum.

For the most part these substances are plant poisons, but quite remarkable benefits have been obtained by their application in very small quantities.

It may very well be that some extremely important discovery may be made as the result of the study of these catalytic fertilisers, one that may throw some light on the question of plant assimilation. Among the most striking results obtained to date appears to be the very remarkable effects produced by some of these metallic salts upon moulds—the effect, for example, of zinc upon the development of *Aspergillus niger*, ten times the quantity of this mould being produced in solutions containing 1 in 50,000 of zinc.

The subject of catalytic fertilisers, or the action of small quantities of substances on plant growth, is an extremely fascinating one, but too little is known of the mechanism of the processes involved to make it desirable to pursue the subject further in this place. It affords additional illustration of the fact that the beneficial action of so-called fertilising substances is not confined to supplying the plant with food.

The minute quantities used are quite inadequate to supply plant-food in the generally accepted sense of the term. For example, Aso, in some experiments with peas, found that the growth of the crop was stimulated, and the yield increased by 0·001 gramme sodium fluoride per 2 to 3 kilos of soil.

Another Japanese investigator found 940 grammes of the same salt per hectare to benefit barley and certain grasses.

In the cases also where these substances act as plant-poisons, the proportions are exceedingly minute. Similarly we know that iron-salts are necessary for the production of chlorophyll, and that in the absence of iron in the soil or culture medium the chlorophyll cells do not develop, and yet chlorophyll itself contains no iron.

There is some action of which we are ignorant in all these cases, for an explanation of which we must wait for the plant physiologist.

Recent work by Willstätter, Marchlewski, and others, has established the fact that a great similarity exists between some of the products of the green-colouring matter of plants and the hæmoglobin or red-colouring matter of the blood of animals and human beings. It has been shown that chlorophyll is a magnesium compound, and contains no iron, which latter is an essential constituent of the red-colouring matter of the blood. It would appear as if the peculiar property of chlorophyll to absorb and split up carbonic acid is due to the presence of magnesium in the chlorophyll molecule, whereas its replacement by iron effects the absorption of oxygen. We know of similar instances in which the introduction into an otherwise inert organic molecule of metallic or elementary atoms results in remarkable physiological activity. Ehrlich's celebrated specific against syphilis (a definite amido-benzol compound containing arsenic) is one of the best known instances in point. Wassermann has used a selenium derivative of eosin successfully in the cure of cancer in mice.

A number of similar compounds are at present under trial, particularly in the case of cancer.

The remarkable effects produced by the entrance of such elementary atoms into the molecule is a fact of the highest significance, not only in the study of disease in men and animals, but in plant physiology also.

The above short review of the work which is being done in the solution of a certain class of soil problems shows that the action of fertilisers is not confined to supplying the crop with food, but that it is far more complex, and that fertilisers influence the physical structure of the soil, and also its biological and chemical condition in a great variety of ways; further, that we have to take into account a large number of factors which affect the fertility of the soil and which are quite independent of its supply of plant-food.

We have seen that fertilisers may exert an influence on the toxic matters produced in the soil, the texture and the moisture-condition of the soil, on the development of bacteria or fungi, on the oxidising power of the soil, and that quite remarkable effects are produced by substances added in quantities much too minute to act as nourishment to the plant.

I do not for a minute desire to underrate the great importance of manuring in maintaining the fertility of the soil. I only wish to emphasise the point that the old conception of manures as acting solely by supplying plant-food must be abandoned.

There are, I venture to think, very few who would nowadays recommend a particular manure formula based, on the one hand, on the composition of the crop, and on the other, on the composition of the soil.

It appears to me that for the next important advance in our knowledge of fertility conditions we must look in the near future to the plant physiologists and the bacteriologists.

The great rôle played by toxic substances, perhaps of bacterial, perhaps of chemical origin, leads us to look for substances which shall restrain their development—for antitoxins.

Just as diseases in men and animals are being combated by the discovery of substances which retard their progress, so it may be hoped that our plant physiologists may be able to discover antitoxins which shall render harmless the poisons which are secreted either by the growing plant or by the metabolism of organic matter in the soil, whether such substances are produced by bacterial agencies or by purely chemical changes. We shall, no doubt, find that many substances which we now apply in the confident anticipation of increased crop production act less by virtue of any special plant-food with which they supply the crop than through their power of retarding or preventing the formation of substances hostile to plant growth.

Soil-analysis will in the future concern itself less with the elaboration of methods for determining the proportions of plant-foods, than in searching for conditions likely to produce toxic substances, and for means to overcome them. Unfertile conditions, whether due to soil-bacteria, fungi, or the formation of poisonous chemical substances, will be combated by the same weapons as are now employed against similar diseases in men and animals.

Whilst there is no intention in all that has gone before to suggest for a moment that we should cease to manure with the recognised fertilisers—potash, nitrogen, and phosphates—or that we should cease to conduct experiments as to the best proportions of these manures for different crops, still I feel that future progress in this matter lies more with actual farmers' experiments, where the principles already established by careful scientific investigations can be tested and modified to suit local conditions. I feel that the time occupied in elaborate manure experiments on the old lines, and in the elaboration of methods of soil analysis on the old lines, would be better spent in the study of other factors productive of soil fertility or infertility—such as some that I have outlined above—and I hope that it may be possible for some of our Australian workers to devote more time to plant hpysiology, to the study of soil toxins, and the elucidation of the conditions which render a soil fertile or infertile—whether these are physical, chemical, or biological in their nature.

APPENDIX.

BIBLIOGRAPHY of literature relating to catalytic fertilisers.

Compiled by L. A. MUSSO (Chemist's Branch).

Iron.

Action of $FeSO_4$ in various soils. P. M. DELACHABRONNY and L. DESTREAUX. (Bieder. Centr. 1889, 9-14.) The addition of $FeSO_4$ to soil increased the yield of wheat up to 3 per cent. of Fe_2O_3, then it decreased. The same with potatoes, with lucerne, and with hay. $FeSO_4$ may be applied at the rate of 300 kilos per hectare dry, or dissolved 5 kilos per 100 litres.

Influence of Iron and $CaSO_4$ in nitrification. P. PICHARD. (Compt. Rend. 112, 1455-1458.) According to the Author, Fe has a good influence in soil nitrification. The addition of $FeSO_4$ is recommended for non-ferruginous soils.

Iron in plant life. G. STAMPANI. (Staz. Sper., Agr. Ital. 19, 5-33.) Manganese cannot take the place of Fe in the formation of chlorophyll.

Iron in plants. A. MOLISCH. (Bied. Centr. 22, 336-338.) Iron occurs in plants partly in a loose form (when it may be extracted with an acid), and partly in a closer union with the plant, and can only be detected in the ash. Algæ and fungi contain very little, but certain lichens contain much Fe, which can be extracted with an acid. A remarkable case is the fruit shell of *Trapa natans*, whose ash contain 68 per cent. of Fe_2O_3. Insoluble Fe is of very general occurrence. . . . . Iron is necessary to fungi, as well as to green plants. Results contrary to this were due to the fact that nutritive solutions were employed which were never quite free from Iron. Fungi are able to appropriate the smallest amount of Fe.

Employment of $FeSO_4$ in agriculture. E. BOIRET & G. PATUREL. (Ann Agron. 18, 418-440.) . . . . Sir H. Davy's opinion, in commenting upon the results obtained with $FeSO_4$ by Pearson, was that $FeSO_4$ produced $CaSO_4$, and on the same theory he explained its injurious action when lime is lacking in the soil. Gris and Dumont in France, and Griffiths in England, had good results (½ cwt. per acre), but not with cereals. . . . . . . $FeSO_4$ is always injurious if the soil does not contain an excess of lime.

Organic compound of Fe in plants. U. Suzoki. (Bull. Coll. Agric. Tokyo Imp., Univ. 1901, 4, 260-266.) The seeds and leaves of *Poligonum tinctorium* and those of *Indigotifera tinctoria* were found to contain 2·84 and 15·5—4·0 and 4·3 of crude ash per cent. The seeds of the first had 12·1 per cent., and those of the second 12 per cent. of Fe_2O_3; the leaves of the first 3·11, those of the second 4·8 per cent. The greater portion of Iron is present in a nuclein-like substance.

Influence of Iron on barley. P. PETIT. (Compt. Rend. 117, 1105-1107.) Barley was grown in sand freed from Fe, to which the necessary ash constituents were added. Fe was supplied (1) in the form of barley nuclein, (2) with Fe as $FeSO_4$, (3) with $Fe_2(SO_4)_3$, (4) no Fe. Nuclein and $FeSO_4$ were both beneficial; $Fe_2(SO_4)_3$ acted as a poison.

Assimilation of Iron from cereals. GUSTAV VON BUNGE. (Zeit. physiol. Chem., 1898, 25, 36-47.) Cereals in comparison with rice are very rich in Iron. The greatest quantity is in the husk or bran. The Author finds the amount of Iron (in milligrams per 100 grams of dry substance) to be as follows:—Rice, 1 to 2; barley, 1·4 to 1·5; wheat-meal, 1·6; barley, 4·5; rye, 4·9; wheat, 5·5; wheat-bran, 8·8.

Bark of *Robinia pseudacacia*. (FREDERICK B. POWER. (Pharm. Journ., 1901 (IV), 13, 258-261.) The bark of Robinia pseudacacia contains a toxic proteid, with about 4 per cent. of ash, which contains a considerable amount of Iron.

Roots of *Dorstenia klaineana*. E. HECKEL & F. SCHLAGDENHAUFFEN. (Compt. Rend., 1901, 133, 940-942.) Roots contain a very large proportion of inorganic matter, the ash consisting of CaO and Fe_2O_3, the latter in large quantity.

Influence of Iron on combustibility of tobacco. G. AMPOLA and S. JOVINO. (Gazzetta, 1902, 32, 367-380.) The Authors give analyses of different kinds of tobacco, and their combustibilities. The factors influencing the combustibility of tobacco are its state of division, and the amount of metals, especially Iron, contained in it.

Stimulants of plant growth, &c. OSCAR LOEW. (Landw. Jahresb, 1903, 32, 437.) . . . . (See Mn.) $FeSO_4$ had a slight effect on oats.

Assimilation of Fe by spinach. O. VON CZADECK. (Zeit. Landw. Versuch. Oesterr, 7, 65-67.) By manuring the soil with 0·5 to 2 per cent. of Fe_2O_3, the percentage of Iron in spinach in pots was increased from 0·03 to 0·18, up to 0·23 per cent. on the dry matter. No effect on growth was observed at first, but later the plants appeared somewhat retarded.

Quantity of Fe contained in spinach. H. SERGER. (Chem. Centr., 1906, 1, 1668; from Pharm. Zeit., 51, 372.) Four samples of spinach contained 86·70 to 89·50 of H_2O, and 9·58 to 13·30 of combustible substance. They yielded 1·907 to 3·108 of ash. 100 grams of dry substance contained, on the average, 0·104 grams of Fe.

An organic vegetable compound of Iron. P. JOSEPH TARBOURICH and P. SAGET. (Compt. Rend., 1909, 148, 517-519.) Of all the plants analysed, *Rumex obtusifolius* is richest in Fe; the dried root contains 0·447 per cent. Fe. This Fe is in a state of organic combination with C, H, N, P, &c., and is soluble in alcoholic HCl.

Aluminium.

Alumina in plants. M. BERTHELOT and GUSTAV ANDRÉ. (Compt. Rend., 1895, 120, 288-290.) Roots of lucerne contain 0·45 to 0·5 per cent. Al_2O_3, those of convolvulus 0·4, of couch grass 0·12 per cent.

Presence of aluminium in vascular cryptogams. A. H. CHURCH. (Proc. Roy. Soc., 44, 121-129.) The Author found it in many Lycopodiæ, in tree-ferns . . . . . in watermoss. The ash of an unknown fern-tree from New Zealand contained 19·65 per cent. of Al_2O_3.

Alumina in plants. L. RICCIARDI. (Gazzetta, 19, 150-160.) From 1·140 to 0·042 per 100 parts of ash.

Effect of aluminium salts on growth of plants. Y. YAMANO. (Bull. Coll. Agric. Tokyo, 1905, 6, 429-432.) Pot exper. with barley and flax, in which ammonia alum (0·2, 1 gram, and 2 grams per kilo of soil) was compared with ammon. sulphate, showed that moderate amount of alums have a stimulating effect on plant development. In water culture 0·2 per cent. alum acted injuriously after three weeks, and 1·8 per cent. killed the plant in a few days.

Alumina in plants. RADKOFER (Ber. Deut. Bot. Gesell, 1904, 22, 216) found in various kinds of *Symploceæ a* colourless substance consisting chiefly of Al salts. These plants were named by Rumphius in 1690 *Arbor aluminosus.*

Alumina in plants. HENRI PELLET and CH. FRIBOURG. (Ann. Chim. Anal., 1905, 10, 373-376.) The Authors have found Al_2O_3 present in very minute quantities in the ashes of sugar-cane and beet-roots.

Influence of aluminium salts on germination. H. MICHAELS and P. DE HEEN. (Bull. Acad. Roy. Belge., 1905, 520-523.) The Authors tested germination of wheat in water. Under these conditions the addition of soluble Al salts is injurious, whereas Al_2O_3, or kaolin, is beneficial.

Aluminium, the chief inorganic element in a protaceous tree, and the occurrence of Al succinate in trees of this species. HENRY G. SMITH. (Journ. Roy. Soc. N.S.W., 1904, 37, 108-120.) Four specimens of *Orites excelsa* (silky oak) were found to contain large amounts of Al Samples of wood from four different sources contained 0·639, 0·684, 0·673, 0·706 per cent. of ash, which contained 79·61, 36·04, 43·03, 38·77 of Al_2O_3 per cent.

When excessive amounts of Al are taken by the trees, deposits of Al succinate are found. The ash of No. 2 contained traces of Co. and Fe. In five varieties of *Grevilleæ* no Al was present.

Influence of aluminium salts on the colour of flowers. VALENTINE VOUK. (Oesterr. Bot. Zeit., 1909, 58, 236-243.) Plants of *Hydrangea hortensis* watered with a solution of 3 per cent. alum. produced flowers of a fine blue colour. Later the plant died. The best results were obtained with 1 per cent. solution. When $Al_2(SO_4)_3$ is used, the colouration is less evident. Negative results were obtained with *Phlox decussata.*

Boron.

Boric acid as a plant constituent. C. A. CRAMPTON. (Amer. Chem. J., 11, 227-232.) The Author found B. in thirty-four out of thirty-six samples of wine, also in watermelon and peach-tree; not in cider nor sugar-cane.

Boron in vegetable ash. E. BECHI. (Bull. Soc. Chim. (3), 3, 122.) The ash of beech growing in borax district of Tuscany contains 1-30,000 of boric acid.

Occurrence of Boron in vegetable kingdom, and its physiological meaning. E. HOTTER. (Landw. Versuchs-Station, 37, 437-458.) . . . . B. was found in all ashes of fruit, leaves, twigs of fruit-trees, and other plants. Water cultures were made with *Piseum sativum* and *Zea mais.* When much B. is taken up, the chlorophyll is destroyed . . . roots die. The greater the concentration, the greater the noxious effects. (Concentration not stated.)

Action of boric acid in germination. J. MOREL. (Compt. Rend., 114, 131-133.) The rate of germination of beans and wheat soaked in acid boric solution (0·01 to 0·1 per cent.) is considerably retarded, the retardation being proportional to the increase of strength of the solution. Plants germinated are weak and etiolated.

Presence of boric acid in products of the soil. A. GASSEND. (Ann. Agron., 17, 352-354.) The Author examined French, Greek, Italian, Spanish, Algerian, Corsican wines, and found boric acid a normal constituent of all, in the proportion of 5 to 10 milligrams per litre. He finds similar traces of boric acid in grapes, apples, potatoes, radishes, lettuce, and some peas, not in all. None in tea, saffron, or cow's milk.

Distribution of boric acid in nature. HENRI HAY. (Compt. Rend., 1895, 896-899.) The Author found wines to contain from 0·009 to 0·033 gram per litre, the mean 0·017 to 0·023 per cent. The ash of the vine contains from 4·7 to 16·5 gram per kilo; the average is 8 to 12 grammes. The ash of the mark from 1·4 to 3·5 per kilo. Leaves only 0·7 per kilo. Fruit, leaves . . . contain from 1·5 to 6·4 grams of boric acid per kilo of ash. In the ash of seaweeds, plantain leaves, chrysanthemum flowers, onions, the quantity is from 2·1 to 4·6 grams per kilo. *Gramineae* and certain fungi absorb very little . . . not more than 0·5 gram per kilo of ash. Ash of coals, of sea salt, river, and spring waters contain B.

Presence of boric acid in genuine Sicilian wines. E. AZARELLO. (Gazzetta, 1906, 36, ii, 375-387.) Eighty-four samples of Sicilian wines all contained boric acid. In six the amount was from 0·0191 to 0·041 grammes per litre.

Use of Boron as a catalytic manure. H. AGULHAN. (Compt. Rend., 1910, 150, 288-291.) The addition of boric acid was found beneficial to wheat grown in nutrient media, unless the amount was higher than 0·01 gram per 1,000 grams of medium. Similar results were obtained under natural conditions in earth. The increased yield (calculated on the dry plant) amounted to 50 per cent. with maize, 21 per cent. with rape-seed, 32 per cent. in case of turnips, when a dose of 0·5 gram or boric acid per square metre was employed.

Presence of Boron in Algerian wines. J. DUGAST. (Compt. Rend., 1910, 150, 838-839.) Traces of Boron have been found in different parts of Algerian vines, notably in the branches, skins, and stones of the berry.

Presence of Boron in Tunisian wines. BERTANCHAUD and GAUVRY. (Ann. Chimie Anal., 1910, 15, 179-180.) Wines from Tunisia were found to contain traces of Boron as a natural constituent.

Tolerance of maize to Boron. HENRI AGULHAN. (Compt. Rend., 1910, 151, 1382-1383.) Plants grown in a medium containing somewhat less than the fatal amount of B. produce seeds, the plant of which has acquired a certain measure of immunity to the poison.

Action of Boron on vegetables. A. and P. ANDOUARD. (Engrais, 26, 942-3.) B. exerted a beneficial influence on, and increased yield of, onions. With beans a slightly depressive action was observed.

Fluorine.

Estimation of fluorine in plants. H. OST. (Ber., 26, 151-154.) Analysis of ash of leaves of various plants, growing under healthy conditions; in all cases a small quantity of F, about 0·01 per cent., was found.

Action of NaF on plant-life. KEIJIRO ASO. (Bull. Coll. Agr. Imper. Univ. Tokyo, 1902, 5, 187-195.) Solutions of 0·05 per cent. of NaF have a more or less injurious effect on the germinating power of seeds. In cases of barley and rice, growth was stimulated by solutions containing 0·001 per cent. NaF; wheat was injured by it. Peas grown in soil were stimulated by small amount, 0·001 gram per 2 to 3 kilos of soil.

Stimulants of plant growth, their practical employment. OSCAR LOEW. (Landw. Jahrb., 1903, 32, 437.) NaF increased the yield both of oats and peas.

Treatment of crops by stimulating compounds. OSCAR LOEW. (Bull. Coll. Agric. Imp. Univ. Tokyo, 1904, 6, 161-175.) . . . fluorine promises to be of agricultural importance.

Action of CaF_2 on Vesuvian soils. GASPARE AMPOLA. (Gazzetta, 104, 34, ii, 156-165.) The soil was very poor in K. The land was manured with superphosphate and $NaNO_3$, and varying amounts of CaF_2. The crops were greatly increased by the use of CaF_2, and so also was the amount of K assimilated by the crops.

Poisonous action of NaF on plants. OSCAR LOEW. (Allg. Bot. Zeit., 94, 330-338.) NaF acts injuriously in two ways—it withdraws Ca from plants, and also acts like an alkaloid.

Stimulating action of CaF_2 on Phanerogams. KEJIERO ASO. (Bull. Coll. Agric. Tokyo Imp. Univ., 1906, 7, 85-89.) . . . . The results of water and soil culture experiments indicated that precipitated CaF_2 probably had some stimulating effect. It is suggested that the better results obtained with Wiborg phosphate as compared with superphosphate may be due to the presence of 1 per cent. of F. in the former.

Stimulating influence of NaF on garden plants. KEJIERO ASO. (Bull. Coll. Agric. Tokyo Imp. Univ., 7, 83-84.) Pot experiments with *Helichrysum bracteatum* and *Pedicularis viscide* showed that 0·02 gram of NaF in 8 kilos of soil increased the yield of *Pedicularis*, but no effect was visible on the *Helichrysum*.

Action of CaF_2 on Vesuvian soil. G. AMPOLA and SANTE DE GRAZIA. (Staz. Sperim. Agr. Ital., 1906, 39, 590-592.) Further experiments showed that the addition of CaF_2 to Vesuvian soils always increased the yield and the quantity of assimilable potassium.

Influence of stimulating compounds on crops. S. UCHIGAMA. (Bull. Imp. Cent. Agric. Stat. Japan, 1907, 1, 37-39.) . . . . NaF had a powerfully stimulating action on *Panicum*, and also increased the yield of barley. The amounts of NaF were 940 and 5,000 grams per hectare.

Presence of Fluorine in grapes. F. LEPERRE. (Bull. Soc. Chim. Belg., 1909, 23, 82-84.) . . . Dried grapes from Malaga and Sultana were incinerated, and 5 grams of the ash tested for fluorine. In most cases the result was negative. According to the Author there should be no F. in genuine wines.

Function of mica in arable soils. BIELER CHATELAN. (Compt. Rend., 1910, 150, 1132-1135.) Exper. in pot culture have shown that the roots of some plants are capable of assimilating the K of insoluble silicates, such as white mica. Mica, with apatite and tourmaline, may be the principal source of the F. found in the plants.

Fluorine in wines. A. KICKTON and W. BEHNCKE. (Zeitsch. Nahr. Genuss., 1910, 20, 193-208.) The Authors have found F. in many wines of 134 samples examined; most gave positive reaction. According to the Authors F. must have been added.

Chromium.

Toxicity of chromium compounds. HENRI COUPIN. (Compt. Rend., 1898, 127, 977-978.) Water culture experiments lead to the following toxic equivalents:—

$K_2Cr_2(SO_4)_2$	$Cr_2(SO_4)_3$	CrO_3	K_2CrO_4	$K_2Cr_2O_7$	Na_2CrO_4
1·142.	0·5.	0·006.	0·(6.	0·03.	0·125.
$Na_2Cr_2O_7$	Am_2CrO_4	$Am_2Cr_2O_7$			
0·0064.	0·06.	0·025.			

Chromic acid is the worst, bichromate less harmful than chromic acid.

The stimulative and toxic effects of various chromium compounds on plants. PAUL KOENIG. Landw. gahresb., 1910, 39, 775-916.) A comprehensive study of the action of chromium on plant life; the action of chromium salts, dichromates and chromates in varying concentrations, either alone or in conjunction with lime, P_2O_5 and various salts, was observed on representatives of numerous natural orders, both in soil and water cultures; and the toxic and stimulative concentrations for each family recorded in tables. The results obtained by other workers, that the higher the degree of oxidation the more toxic its effect, were confirmed.

Chromium in soil. C. J. WARDEN. (Chem. News, 63, 85.) Soil from Andaman Islands. This soil from a coffee plantation contained 1·6134 per cent. of chromium oxide.

Copper.

Copper in various parts of the vine. F. SESTINI. (Staz. Sperim. Agrar. Ital., 24, 115-132.) One vine died, presumably having been watered with a solution of $CuSO_4$. Four samples of vine leaves not treated with $CuSO_4$ contained 0·00047 to 0·00056 to 0·00060 and 0·00054 per cent. of copper.

Effect of Cu salts on the growth of the vine and on soil. BERLESE and LIVIO SOSTEGNI. (Bied. Centralb., 1895, 24, 768-769.) . . . . When the roots of a vine were allowed to grow in a 1 per cent. solution of $CuSO_4$, Cu could only be detected in the roots. Cu remains in the soil as oxyhydrate of the basic sulphate, or as a double salt of Cu and Ca. The basic sulphate being readily decomposed by CO_2, dissolves, and is absorbed by plants.

Toxicity of copper salts. ALEXANDER TSCHIRCH. (Ann. Agron., 1895, 21, 544.) Contrary to what is generally supposed, copper is not poisonous to plants. Whilst the sulphate, nitrate, and chloride are corrosive, plants take up copper without injury from soils containing copper compounds. Haricots grew better in nutritive solutions to which 0·06 per cent. of copper oxide was added, than in absence of copper. Frank and Kruger (Ann. Agron., 1895, 21, 42) showed that the copper-lime preparation had a beneficial effect on the development of potatoes.

Poisonous effects of cupric salts on higher plants. HENRI COUPIN. (Compt. Rend., 1898, 127, 400-401.) Experiments on young wheat plants lead to the following toxic equivalents, which represent the minimum quantity of the salt that must be dissolved in 100 parts of water to kill the plants:—Cu bromide 0·004875, Cu chloride 0·005, $CuSO_4$ 0·005555, Cu acetate 0·005714, Cu nitrate 0·0061. It seems clear that the effect is due to the Cu ion. It follows that the use of solutions of cupric salts as germicides is attended with considerable risk.

Presence of copper in plants, and the amount they may contain. EDOUARD HECKEL. (Bull. Soc. Botan. de France, 1899, 46, 42-43.) Analysis of *Policarpea spirostylis* are given, showing one sample containing 30 milligrams of Cu per 1,000 grams of dry matter, whilst other plants growing in soils very rich in copper contained as much as 500 milligrams per kilo. In Australia the presence of *Policarpea* is thought to be an indication of copper in the soil. The ash of the seeds of *Quassia gabonensis* were found to contain 0·698 per cent. of Cu; the ash of the seed without the seed coat contained only 0·254 per cent. *Viola calaminaria* is said to contain a considerable quantity of zinc; and the presence of the plant usually indicates Zn in the soil.

Pot experiments with soils containing Cu. ALB. STUTZER. (Landwirt Sch. Versuchs-Stat., 1906, 65, 285-288.) *Trifolium pannonicum* was grown in pots containing 10 kilos of sand mixed with garden soil. Two pots received

Cu finely powdered, 10 grams and 1 gram respectively. Two pots respectively 10 grams and 1 gram of CuO. No injury was observed, except in pot with 10 grams CuO, where the plant failed to grow.

Action of different amounts of Cu in soil on the growth of plants. J. SIMON. (Landw. Versuchs Station, 1909, 71, 417-429.) Experiments with 0·001 and 0·01 of $CuSO_4$ per cent. of soil gave reduced yields.

Influence of some metallic compounds on the growth of wheat. V. NASARI. (Atti. R. Accadem. Lincei., 1901 (v), 19, ii, 361-367.) $CuSO_4$ affected the growth unfavourably.

Sulphur.

Action of flowers of sulphur on vegetation. E. BOULLANGER. (Compt. Rend., 1912, 154, 369-370.) The addition of small quantities of flowers of sulphur to soil improves the yield of plants, such as carrot, haricot, potatoes. As this improvement is more marked with ordinary soils than with sterilised material, it would seem that S. acts indirectly by modifying the development or activity of bacterial flora. The quantity used was 7 decigrams to 30 kilograms of soil.

The fertilising action of Sulphur. A. DELNOLON. (Compt. Rend., 154, 524-526.) The beneficial effects of crude gas-works ammonium salts must be partly attributed to free S, as the amount of N and its state of combination in crude ammonium salts residue from gas-works is insufficient to account for it.

Amount of sulphur in plants. SERGEI M. BOGDANOFF. (Journal Russ. Phys. Chem. Soc., 31, 471-477.) Estimation of S. in vegetable ashes gives incorrect results, except when small amounts of HNO_3 are added. Plants contain much more S than is indicated in Wolf's tables, and the Author believes the estimation of H_2SO_4 in soils to be of practical importance. In some Russian soils certain crops gave considerably higher yields after manuring with sulphates.

Application of CS_2 in mulberry culture. J. N. SIRKER. (Imp. Coll. Agric. Tokyo, 1909, 1, 185-187.) Application of CS_2 to the soil (450 c.c. to 16 square metres) increased the yield of mulberry leaves by 44 per cent.

Sulphur in soils. W. H. PETERSON. (J. Amer. Chem. Soc., 1911, 33, 549-564.) The Author's results show that considerable quantities of S are removed from the soil by common crops. In cases in which farm manure had been regularly and liberally applied, the S contents had been maintained, or even increased. Suitable sources of S are farm manure, superphosphates, K_2SO_4, $CaSO_4$, &c.

The fertilising action of Sulphur. L. DEGRULLY, Montpellier. (Progres Agric. et Vitic., 57, 321-324.) Experiments during 1911 showed that the addition of 100 grammes of Sulphur per square metre doubled the crop of beets, and increased that of turnips 33 per cent. A great part of S appears later in the soil as sulphates. Increased crops may be due to sulphates formed or to the direct stimulating effect on S on plant.

Action of Sulphur on vegetation. E. CHANCRIN and A. DESSIOT. (Journ. Agr. prat., 21, 427-429.) In Germany the use of S for potato diseases was not only effective in reducing the disease, but increased the yield of potatoes. The Authors report experiments in which S was used at the rate of 250 to 500 kilos per hectare in conjunction with superphosphate, K_2SO_4 and $NaNO_3$.

Sulphur as a fertiliser. D. HERLINGER. (Wiener Landw. Ztg., 62, 132-133.) Sulphured rows of potatoes gave higher yields, but because of unfavourable weather, other contributing causes are not excluded.

Iodine.

Absorption of Iodine by plants. PAUL BOURGET. (Compt. Rend., 1899, 129, 768-770.) Twenty-eight plants of nine different orders were grown in carefully prepared soil, containing 0·83 milligrams of Iodine per kilo. Cut when mature, and Iodine estimated. Iodine was found to vary from nil (in potato, gherkin, black radish, parsley, carrot, chicory, endive) to 0·32 (in green haricots), 0.38 (in *Beta cycla*) up to 0·94 (in garlic) milligrams per kilogram.

Action of Iodine on growth of plants. S. SUZUKI. (Bull. Coll. Agric. Tokyo Imper. Univers., 1902, 5, 199-201.) KI at the rate of 0,006 gram in 2 to 3 kilos of soil increased the growth of peas, both as regards straw and seed.

Stimulants of plant growth, their practical employment. OSCAR LOEW. (Landw. Jahrb., 1903, 32, 437.) . . . (See Mn.) . . Small amounts of KI had good effect.

Stimulating action of KI on sesamum and spinach. S. UCHIYAMA. (Bull. Imper. Centr. Agric. Exper. Station, Japan, 1906, 1, 35-37.) Small amounts of KI increased yield both of sesamum and spinach. In pot experiments with sesamum there was an increase of 16 per cent. when KI was added, at the rate of 124 grammes per hectare, and 25 per cent. when ten times that quantity. In a field experiment on a plot having an area of 59·5 square metres, the yield was increased 24 per cent. by 25 grammes of KI. The results are interesting, as it is usual along the coast to employ seaweed as a manure.

Influence of stimulating compounds on crops. S. UCHIYAMA. (Bull. Imp. Centr. Agric. Exper. Stat., Japan, 1907, 1, 37-79.) KI increased the yield of *Panicum miliaceum* by 28 per cent., and barley by 34 per cent., the most suitable amount being 376 and 500 grammes per hectare respectively.

Function of Iodine in marine Algæ. FRANCESCO SCURTI. (Gazzetta, 1906, 36, ii, 619-625.) The Author experimented on *Sargassum linifolium*; he concludes that Iodine holds in algæ the place that Cl holds in phanerogams.

Lithium.

Behaviour of plants toward Lithium salts. CIRO RAVENNA and M. ZAMORANI. (Atti. R. Accad. Lincei., 1909 (v), 18, ii, 626-630. Finding that the ash of tobacco leaves contains sufficient Li to impart a marked colouration to a flame, the Authors have investigated the effect of Li_2SO_4 on various plants. On tobacco and potatoes no toxic action was observed, but some on oats, and more marked on beans.

Action of Lithium and Cæsium on vegetation. M. KATAMURA. (Bull. Coll. Agric. Tokyo, 1904, 6, 153-157.) Li_2CO_3 has a slightly stimulating effect on barley and peas.

Influence of salts of Lithium and Cæsium on wheat. J. A. VOELCKER. (J. Roy. Agr. Soc. Eng., 71, 344-5.)

Cæsium.

Cæsium as a manure. M. KATAMURA. (See above *re* Lithium.) CsCl, at the rate of 0·1 gram per kilo of soil, slightly increased the yield of rice.

Uranium.

Stimulants of plant growth. OSCAR LOEW. (Bull. Agric. Imper. Univ. Tokyo, 1902, 5, 173-175.) Solutions of 0·01 per cent. Uran. nitrate increased the yield of peas and oats; solutions of 0·2 per cent. were fatal in three days.

Stimulants of plant growth, and their practical employment. OSCAR LOEW. (Landw. Jahrb., 1903, 32, 437.) Uranyl nitrate increased the yield both of oats and peas.

Titanium.

Presence of Ti in plant ash. CHARLES E. WAIT. (J. Amer. Chemic. Soc., 1896, 18, 402-404.) Titanium occurs in every plant ash that the Author has examined. . . . Ash from coal contains Ti, Pennsylvania anthracite coal as much as 2·59 per cent. According to Author, Oakwood ash contains 0·31, cow pea ash 0·01, apple and pear wood ash 0·21. Cotton seed meal has 0·02 of Ti.

Nature of the colour of the black cotton soil of India. H. E. ANNETT. (Mem. Dept. Agric., India, 1910, 1, 185-203.) The dark colour is due to a mineral containing 18·07 per cent. of TiO_2

Manganese.

(*a*) Presence of Manganese in Plants.

SCHEELE. (Memoires de Chimie, Dijon, 1785.) The ash of the seed of the wild anise contains a small amount of Mn; a considerably larger amount occurs in the stems of the same plant.

HEBAPATH. (Cited by Rousset, Ann. Sci. Agron., 3 sec., 4 (1909), II, p. 82.) Found Mn in the ash of radish, beet, and carrot.

SALM-HORSTMAR. (Journ. prakt. Chem., 46 (1849), p. 193.) Mn occurs in the ash of oats.

J. LIEBIG. (Familiar letters on chemistry, London, 1851, 3 ed., pp. 458-459.) Tea contains manganese.

HILGARD. (Rpt. Geol. and Agr., Mississippi, 1860, p. 360.) The ash of the long-leaf pine from Mississippi contains in some instances a relatively large percentage of manganese.

LECLERC. (Compt. Rend., 75, 1872, p. 1213.) The Author, from his investigations, concludes that Mn is a universal constituent of soils, and likewise occurs in many plants.

MAUMENE. (Compt. Rend., 98, 1884, p. 1418.) The parenchyma of cabbage leaves contains only a trace of Mn, but the veins contain considerable quantities.

H. BRIDGES and W. WATSON. (Chem. News, 1899, 79, 154-167.) The Authors have found Mn present in the ash of Cardamoms. (Amount not stated.)

A. B. GRIFFITHS. (Compt. Rend., 1900, 131, 422-423.) Mn is present in the ash of sarsaparilla, hydrastis, cardamom, oak, rhatany, and belladonna.

CHARLES F. SCHLAGDENAUFFEN and E. REEB. (Compt. Rend., 1904, 980-983.) The residue after incinerating the light petroleum extract of ripe barley consists of P_2O_5 and phosphates of Ca, Mn, Fe, which existed in the plant as metallic derivatives of lecithin.

N. PASSERINI. (Boll. Instit. Agrar. Scandicci, 1905 (ii), 6, 3-14.) Lupins were grown in a soil containing, when dry, 0·068 per cent. of Mn. The Mn percentage in the ash, as Mn_2O_2, was: leaves 12 per cent., stems 4·5 per cent., nodules 0·3 per cent. Pot experiments in sand containing 0·0002 of Mn. per cent., with and without addition of $MnCO_3$, showed no apparent difference. The dry matter of the plants grown with $MnCO_3$ contained 0·0095 Mn, with $MnCO_3$ 0·0636 per cent.

O. PRANDI and A. CIVETTA. (Staz. Sper. Agr. Ital., 1911, 44, 66-83.) Twenty-four wines analysed all contained Mn. Mn. equals 0·53 or 1·5 per million. Usually, the better the wines, the more Mn.

(*b*) Manganese as a Manure.

E. GIGLIOLI. (Ann. R. Scuola Sup. Agr. Portici, 2 ser. (1901), p. 133.) Mn applied at the rate of 102 lb. per acre in some wheat experiments. In some instances it resulted in an increase, in some instances a decrease, of yield.

ASO. (Bull. College of Agr. Tokyo Imp. Univ., 5, pp. 177-185.) The Author cultivated barley, radishes, wheat, and peas in culture solutions containing $MnSO_4$, and concludes that in sufficiently dilute solutions Mn exerts a stimulating effect. He finds that in concentrated solutions Mn exerts a toxic effect, greatest in cold weather.

LOEW and SAWA. (Bull. Coll. Agr. Imp. Univ. Tokyo, 5, 161-172.) By adding a small amount of $MnSO_4$ to culture solutions, a considerable increase in the growth of barley, rice, cabbage, beans, and peas was effected. Same results were obtained in pots.

NAGAOKA. (Bull. Coll. Agr. Tokyo Imp. Univ., 1902-3, 5, pp. 467-472.) The Author grew rice in soil in boxes, to which $MnSO_4$ was applied, with a general fertiliser. The increased growth of rice was found to be proportional to the Mn applied up to 44 lb. per acre, larger applications bringing about the same result. The following year, without any further application, an increase of 17 per cent. was noticeable.

NAGAOKA. (Bull. Coll. Agr. Tokyo Imp. Univ., 1906, 7, pp. 77-81.) The above detailed experiments were continued, using Mn sulphate, chloride, and carbonate. The season was very unfavourable to the growth of rice; in most instances a decrease of yield was obtained. The fact that increased growth had been obtained the two previous years by application of Mn, according to the Author, may have partially exhausted the available plant food, so as to bring about the need for a general fertiliser.

OSCAR LOEW. (Landw. Jahrb., 1903, 32, 437.) Small amounts of $MnSO_4$ increased the yield, providing the manuring was normal, the effect varying with the different families of plants. Crucifers seem more sensitive than Gramineæ. In rice the relation of grain to straw was improved by Mn, as well as the yield.

OSCAR LOEW and SEIROKU HONDA. (Bull. Imp. Univ. Tokyo, 1904, 6, 126-130.) $MnSO_4$ applied to *Cryptomeria japonica* more than doubled the weight of the tree in eighteen months.

OSCAR LOEW and SEIROKU HONDA. (Bull. Imp. Univ. Tokyo, 1904, 6, 136-137.) Joint application of Fe and Mn had a distinct effect in increasing the yield of flax, whilst separated had less effect.

JOHN A. VOELCKER. (Journ. Roy. Agr. Soc., England, 64 (1903), p. 348; 65, (1904), p. 306.) In pot experiments the Author found a decrease in the growth of wheat and barley by using MnI_2, while nitrate and phosphate had a good effect. Germination and sprouting were retarded by Mn_2O_3 and $MnSO_4$, while a deeper green and more luxuriant growth were obtained with $MnCl_2$.

GABRIEL BERTRAND. (Compt. Rend., 1905, 141, 1255-57.) Soil was clayey, and contained 0·057 per cent. of Mn soluble in HCl (0·024 soluble in acetic acid). Oats were grown in plots of 20 acres; to one was added $MnSO_4$, at the rate of 50 kilo per hectare. The gain was 17 per cent. of grain, and 26 per cent. of straw. The grain produced with Mn weighed 46·5 kilos per hectolitre, without Mn 44 kilos. The grain of both plots contained the same amount of Mn, 0·000004 per cent.

BERTRAND and THOMASSIN. (Compt. Rend., 141, 1905, p. 1256.) Oats grown in a soil containing 0·057 per cent. Mn gave a considerable increase in yield when $MnSO_4$ was applied. The general appearances were the same in both plots, but there was a notable difference in yield.

STRAMPELLI. (Atti. 6° Congresso Internaz. Chimica Applic., 4, 1906, pp. 14-17.) The Author reports considerable increases in the yield of various grains by the use of $MnSO_4$, $MnCl_2$, MnO_2.

H. MICHAELS and P. DE HEEN. (Bull. Acad. Royale Belge., 1906, 286-289.) Colloidal solutions of Mn have a slightly more stimulating effect on germination of plants than similar solutions of tin.

GIOVANNI SALOMONE. (Staz. Sperim. Agrarie Ital., 1906, 38, 1015-1024.) Small quantities of Mn have a beneficial influence, large are toxic. . . . Small quantites of MnI_2 exerted a favourable influence on germination of cabbage and carrot seeds.

JOHN A. VOELCKER. (J. Roy. Agric. Soc. England, 1905, 66, 206-211.) In the case of wheat, soaking the seed in solution of Mn and $FeSO_4$ (no more than 2 per cent.) is beneficial to germination. K and Na silicates are beneficial to wheat and barley.

TOMIO KATAYAMA. (Bull. Imper. Coll. Agric. Univ. Tokyo, 1906, 7, 91-93.) Whilst $MnSO_4$ (0·015 per cent.) gave with peas an increase of 50 per cent. on straw and 25 per cent. on seed, in case of cereals the increase was only 10 per cent.

MUNESHIGI NAGOOKA. (Bull. Coll. Agri. Imper. Univ. Tokvoo. 1906. 7, 77-81.) Experiments with rice were repeated in 1904. $MnSO_4$ was applied at different rates, from 30 to 170 kilos per hectare. The greatest gain was with 77 and 107 kilos per hectare, about 15 per cent.

ASO. (Bull. Coll. Agr. Tokyo Imp Univ., 1907, 7, 449-453.) Further experiments with rice and $MnCl_2$ resulted in slight increase in yield, less than former years. Where Mn was used in addition to a liberal application of other fertilisers, scarcely any effect was produced, while with soils which had been continuously cultivated without a general manure it gave an increase of 23·5 per cent. Summing up the results, Aso states: "On the manganese plots the increase was relatively greatest where the manuring conditions were less favourable."

MOLINARI and LIGOT. (Bull. Agr. (Brussels), 23, 1907, p. 764.) The Authors conducted a series of pot experiments with oats, using a soil containing from 0·01 to 0·07 per cent. Mn. In addition to a complete fertiliser, $MnSO_4$

was applied, from 0·05 to 0·20 grams per pot. The maximum increase in yield was obtained by the application of 0·10 gram per pot; use of larger quantities only producing slight increases.

W. van Dam. (Chem. Weekblad, 1907, 4, 391-397.) When seeds are soaked in $MnSO_4$ solution, or $MnSO_4$ is used as a fertiliser, the yield is increased.

Giovanni Salomone. (Staz. Sper. Agrar. Ital., 40, 1907, 97-117.) Experiments in the fields confirm the results. (See previous abstract.) $MnSO_4$, $Mn(NO_3)_2$, and MnO_2 exert the most beneficial influence on corn. A table is given showing the useful and toxic proportions. One grain Mn per square metre improved growth of meadow grass. Fifty kilos of $MnSO_4$ per hectare benefit wheat; above this quantity, toxic.

Kjalma von Feilitzen. (J. Landw., 1907, 55, 289-292). The soil, chiefly decomposed sphagnum peat, had been under cultivation since 1894. An application of 10 kilos of $MnSO_4$ per hectare had no effect on oats.

S. Uchiyama. (Bull. Imp. Centr. Agric. Exper. Station, Japan, 1907, 1, 37-39.) Plots experiments. The soil was a diluvial loam, rich in organic matter, containing 0·414 of $MnSO_4$ soluble in hot HCl, and 0·076 soluble in citric acid 1 per cent. Wheat and barley showed very little effect with $MnSO_4$, whilst grasses, buckwheat, radishes, carrot, *Brassica campestris*, and tea plants were considerably benefited. The amount of $MnSO_4$ varied from 10 to 37·5 kilos per hectare as Mn_3O_4. Better results were obtained when applied as a top-dressing. Further experiments in bottomless cylinders showed that with barley the grain and total yield increased 18 per cent. up to 24 per cent. by 25 kilos of Mn_3O_4 per hectare.

Walter F. Sutherst. (Transvaal Agric. Journal, 1908, 6, 437.) Experiments in pots 3 feet high, with an area of about 1 square yard. Mn was applied as $MnCl_2$ 2 grammes, $MnSO_4$ 2 grammes, and Mn_2O_2 5 grammes per pot. Mn_2O_3 gave the best results.

Ach. Gregoire, J. Hendrick, and Em. Carpiaux. (Bull. Ind. Chim. Bacter. Gembloux, 1908, N. 75, 66-72.) Fifty kilos per hectare of $MnSO_4$ gave an average increase of 7 per cent. Smaller amounts, 10 kilos, no effect. No sensible results in case of sugar beet.

John A. Voelcker. (Journ. Roy. Agric. Soc. England, 1907, 68, 264-266.) LiCl and Li_2SO_4 had a bad effect on wheat. $FeSO_4$, $MnCl_2$, and $MnSO_4$, not more than 1 cwt. per acre, acted beneficially.

Sigurd Rhodin. (K. Landtbr. Akad. Handl. Tidskr., Stockholm, 1908, 30-32.) Experiments inconclusive.

T. Takeuki. (J. Coll. Agr. Imp. Univ. Tokyo, 9109, 1, 207-10.) Different plants were grown in the same soil in pots, both with and without $MnSO_4$ ($MnSO_4$ 4 H_2O, 0·2 grams in 8 kilos of soil). The increase due to Mn was as follows:—Barley 5·3, flax 13·9, pea 19·4, spinach 41 per cent.

M. de Molinari. (Ann. Gembloux, 1908, 609.) Manganese, zinc, copper, and ferrous sulphate failed to increase the yield of oats and barley. The soil contained, however, a good deal of manganese.

F. Mach. (Ber. Grossh. Bad. Landw. Versuch Anst. Augustenb, 1910, 51, 5.) Application of $MnSO_4$ in pots and field experiments seemed to have no result on the growth of tobacco.

V. Nasari. (Atti. R. Accad. Lincei, 1910 (v), 19, ii, 361-367.) From experiments in laboratory and in the field on germination of wheat the Author finds MnO_2, $MnSO_4$, $MnCO_3$ to exert a favourable influence on the growth of the plant.

Bartmann. (Journ. Agr. prat. n. ser., 20 (1910), N. 47, p. 666.) The Author describes some experiments where Mn was applied as $MnCl_2$, $MnCO_3$, MnO_2, $MnSO_4$, and two products from Mn mines, consisting primarily of Mn_2O_3 and Mn_3O_4. Beets, peas, and beans were considerably increased in yield by $MnCO_3$, whilst MnO_2, $MnCl_2$, $MnSO_4$ had but little effect, as also the products from the mines.

JOHN A. VOELCKER. (J. Roy. Agric. Soc. England, 1910, 71, 343-350.) Small amount of Li (Li—0·0018 per cent.) seems to have a stimulating effect on wheat, no injury if under 0·002 per cent. Cs salts may be employed up to 0·0036 per cent. without injury. Zn salts are injurious when soil has 0·04 per cent. zinc. Barley showed better result with $FeSO_4$ (0·02 per cent.), and $MnSO_4$ (0·005 to 0·06 per cent.) similar effects with soil.

P. LEIDRETER. (Inaug. Diss. Rostock. Bied. Zent., 1911, 40, 531-535.) Manganese gave good results with oats, beans, mustard, sugar-beet, mangold.

A. CARLIER. (Ann. Gembloux, 1910, 423.) $MnSO_4$ applied at the rate of 50 and 100 kilos per hectare increased yield of hay up to 0·9 and 9·5 per cent.; it reduced yield of potatoes by 9 and 0·6 per cent.; it reduced yield of mangolds (roots) by 2·5 and 1 per cent.; it reduced yield of leaf of mangolds by 2·5 and 20 per cent.

L. BERNARDINI. (Staz. Sperim, Agr. Ital., 1910, 43, 217-240.) The chief effect of Mn is the production of Ca and Mg soluble compounds from insoluble forms, so that Mn may be considered as an indirect Ca and Mg manure.

J. STOCKLASAI. (Compt. Rend., 1911, 152, 1340-1342.) The author confirms Bertrand's experiment on the beneficial effect of Mn on plant development. Nutrient solution containing 1-1,000 of the gram atomic weight of Mn and Al per litre increased the yield of the plant, but if both are present a toxic effect follows. The best results are obtained from solutions containing half the above quantities.

THEODORE PFEIFFER and E. BLANCK. (Landw. Versuchs Stat., 1912, 77, 33-66.) Experiments in pots and small pots are described. . . . Conclusion: under some conditions Mn salts may have favourable effect on plant development; it is, however, doubted whether the action of Mn is of practical importance, and more evidence is required before its employment can be recommended.

H. BARTMANN. (Journ. Agr. prat., 20, pp. 666-7.) The yield of potatoes and sugar-beet was greatly increased by Mn salts. The greatest yield was obtained from using 176 to 352 lb. to the acre.

LUIGI MONTEMARTINI. (Pavia Bot. Instituto. from Staz. Sper. Agr. Ital., 44, 564-571.) Experiments show that $MnSO_4$ as well as $CuSO_4$ in very dilute solutions exert a strong stimulating action.

A. and P. ANDOUARD. (Engrais, 26, 915-6.) The Authors experimented with wheat, potatoes, carrots, and kidney beans. Mn increased the yield of wheat and beans, but slightly decreased the yield of carrots and potatoes.

Y. FUKUTOME. (Bull. Coll. Agr. Tokyo, 1904, 6, 126-130.) The joint application of Iron and Manganese had a distinct effect in increasing the yield of flax; separately they had less effect. Cobalt nitrate (0·02 gram in 8 kilos of soil) had also a stimulating effect.

(c) Influence of Manganese on Alcoholic Fermentation.

E. KAYSER and H. MARCHAND. (Compt. Rend., 1907, 145, 343-346.) More complete fermentation is obtained by using yeasts accustomed to the presence of Mn.

E. KAYSER and H. MARCHAND.. (Compt. Rend., 1907, 144, 714-716.) Mn has a beneficial effect.

E. KAYSER. (Compt. Rend., 1910, 151, 816-817.) $MnNO_3$ is more active than KNO_3 in alcoholic fermentation.

d) Manganese as a Toxic Agent.

W. P. KELLEY. (Journ. Ind. Eng. Chem., Vol. I, p. 533.) The Author finds Mn in Hawaiian soils which are toxic to pine-apple.

F. B. GUTHRIE and L. COHEN. (Journ. Roy. Soc. N.S.W., Vol. 43, p. 354-60.) Two samples of the same soil. one in normal condition, and the other from patches where grass would not grow, analysed, showed the presence in the second one of 0·254 per cent. of Mn_2O_3, which was quite absent in the first. The Authors attribute the sickness of the soil to the Mn present.

W. P. KELLEY. (Hawaii Agr. Exp. Stat. Bull., No. 26.) A long and interesting work on the action of Mn on Hawaii vegetation. The Author has found that some plants are affected by Mn and some not. In practically every instance a modification of the mineral balance in the ash was observed.

The ratio of absorbed lime to absorbed magnesia increased under the influence of Mn, regardless of whether the plant showed a toxic effect or not. According to the Author, the effects of Mn are largely indirect, and are to be explained by its bringing about a modification in the osmotic absorption of lime and magnesia; and the toxic effects are chiefly brought about through this modification rather than as a direct effect of Mn itself. As not all species of plants are equally sensitive to modifications in the lime-magnesia ratio, likewise the effect of Mn may be very different in different species of plants. In practice it has been found that the addition of lime to manganiferous soils increases toxic power; on the other hand, the addition of soluble superphosphate counterbalances, in many cases, the influence of Mn.

(Hawaii Forester Agr., 8, 176-8.) The Author assumes the toxic action of Mn in Hawaii Mn soils is due to the action of Ca manganite primarily, and to the secondary action of other salts and acids upon the Ca manganite.

J. Hudig. (Landw. Jahrb., 40, 613-644.) In the peat settlement of Gröningen and Drent plant sickness is evident, especially oat sickness. The cause is the organic matter of the soil. Though Mn in the sick soil is as large as in the sound soil, the addition of Mn salts ($MnSO_4$, MnO_2) had a beneficial effect on the soil, especially in its after-effects.

James Burmann. (Bull. Societ. Chim., 1911 (IV), 9, 957-959. *D. ambigua* and *D. lutea* are indigenous to Switzerland, whilst *D. purpurea* can only be grown in the garden, and does not reproduce itself. This seems to be due to the fact that the two former do not require Mn, whilst the third does. *Digitalis* leaves grown on soil derived from ferruginous grit in Alsace gave 5·08 of ash, containing 9·02 per cent. of Mn. 0·80 per cent. of Fe, whilst the grit itself contained 0·43 per cent. of Mn and 4·82 per cent. of Fe. The presence of Mn in the ash serves to distinguish *D. purpurea* from *D. ambigua* and *D. lutea*.

Masoni Giulio.. (Staz Sper. Agr. Ital., 64, 85-112.) From the researches of the Author it would appear that Fe cannot be displaced by Mn. $MnSO_4$ in the soil is transformed into an insoluble compound ($MnCo_3$).

(*e*) Influence of Manganese on "Aspergillus Niger."

G. Bertrand. (Compt. Rend., 1912, 154, 381-383.) Taking the utmost precautions to avoid the presence of traces of Mn, it is found that the addition of a minute amount of Fe and Zn does not induce sporulation. The addition of a trace of Mn salt, however, brings about profuse formation of conidia, and the mycelium acquires a velvety black appearance. . . . For sporulation the three metals must be present. Ferrous sulphate contains Mn; the purest commercial specimen contains 0·2 to 0·5 milligram of Mn per gram.

Gabriel Bertrand. (Compt. Rend., 1912, 154, 616-618.) By taking elaborate precautions to secure an artificial culture medium free from Mn, the Author has been able to show that very minute doses of Mn (one part in 10,000,000,000) have an appreciable effect in increasing the yield of *Aspergillus*. Mn was separated in special way (described). Vessels of quartz were employed.

Miscellaneous and unclassified.

Ashes of sugar-beet. E. O. v. Lippman. (Ber. 21, 3492-3493.) The Author found boric acid, vanadium, manganese, cæsium, and copper in minute quantities.

Presence of Boron, Lithium and Copper in plants. N. Passerini. (Staz. Sper. Agr. Ital., 20, 471-476. Ash of tomatoes, chick-peas, *Iris germanica*. Boron and lithium were nearly always found, copper also in tomatoes, and in chick-peas, in the proportion of 0·082 per cent. of ash, and in *Iris germanica* as much as 0·022 per cent. of the ash.

Injurious action of Nickel on plants. E. Haselhoff. .(Landw. Jahresb., 22, 862-867.) . . . In order to ascertain the effect of Ni on plants, horse-beans and maize were grown in nutritive solutions, to which $NiSO_4$ was added (from 2·5 to 50 milligrams per litre). The smaller amount (2·5 per thousand) was sufficient to kill the plant.

Lime and Lupins. HEINRICH. (Bied. Centr., 1896, 26, 231-232.) The result of the addition of 0·5 to 1·5 up to 10 per cent. of chalk to sandy soil, showed even the smallest amount to be injurious to lupin. At the rate of 1 per cent. $CaSO_4$, reduced the crop by 50 per cent. $Ca_3P_2O_8$, at the rate of 0·5, appeared injurious. $MgCO_3$, at the rate of 0·5 per cent., killed the plant.

Selective absorption of certain elements by plants. E. DEMOUSSY. (Compt. Rend., 1898, 127, 970-972.) The plants were grown in different solutions, such as KNO_3 and KCl, each containing two salts, Ca and K, Na and Ca, K and Na. The plants exercised a selective action.

Barium in plant and soil. RICHARD HORNBERGER. (Landw. Versuch Stat., 1899, 91, 473-478.) The ash of different parts of the trunk wood of two copper beeches, 100 years old, were found to contain from 0·97 to 1·20 and 0·57 to 0·90 per cent. of barita. The soil contained a small amount of BaO. (400 grammes extracted with hot HCl, 5 per cent., gave 9 milligrammes of $BaSO_4$. Ba was also found by Forchammer (Ann. Phys. Chim., 1855 (i), 95, 60) in the ashes of beech, oak, and birch; and by Boedecker and Eckard (Annalen, 1856, 100, 244) in beech wood and in the sandstone near Gottingen. It also occurs in the Nile mud (Knop Landw. Versuchstat, 17, 65), and in the wheat grown in the Nile Valley (Rworzack, ibid., 398).

The role of sodium in plants. M. STAHL SCHRODER. (Chem. Centr., 1899, ii, 693, from J. Landw., 47, 49-84.) . . . In accordance with Contejean and Guitteau's results, Na remained mainly in the lower parts of the plants. Oats can assimilate large amounts of sodium without injury.

Plants containing Zinc. ERNEST FRICKE. (Chem. Centr., 1900, ii, 769, from Zeit offentb. Chem., 6, 292.) On a meadow near Randsbeck, in Westphalia, which is occasionally flooded by waste liquors containing Zinc, and on a soil near Bockwiese and Lautenthal, which is known to contain zinc, a cruciferous plant very similar to *Arabis Halleri* has been found to flourish. In both cases the plant contained zinc; and in the latter case the plant substance free from water and sand yielded 1·3 per cent. of ash, which contained 0·94 per cent. Zn.

Ivy as a calcareous plant. W. VON KLENKE. (Zeit. Landw. Versuch. West Oester, 3, 629-630.) The air-dried wood of ivy yielded 2·57 per cent. of ash, containing 31·09 per cent. of lime and 4·52 per cent. of MgO. Ivy is thus undoubtedly a calcareous plant. It is not suitable for fodder, and is almost free from parasites.

Mercurial poisoning of green plants. FRANZ W. DAFERT. (Zeit. Landw. Versuchs. West Oesterr., 4, 1-9.) Plants grown under a jar over mercury were killed by its vapour.

Pot experiments of the action of NaI, and NaBr and LiCl on crop. J. AUGUSTUS VOELCKER. (Journ. Roy. Agric. Soc. England, 1900 (iii), 11, 566-591.) NaI, at the rate of 2 cwt. per acre, NaBr of 1 or 2 cwt. per acre, LiCl at the rate of 5 cwt. per acre, had injurious effects on wheat, barley, clover.

Presence of copper in plants, and the amount they contain. EDOUARD HECKEL. (Bull. Soc. Botan. de France, 1899, 46, 42-43.) . . . *Viola calaminaria* is said to contain considerable quantities of zinc, and the presence of the plant usually indicates zinc in the soil.

Toxic action of the compounds of alkaline earth metals toward higher plants. HENRI COUPIN. (Compt. Rend., 130, 791-793.) A study of the action of Ca, Sr, Ba on wheat. With soluble homologous compounds the toxic effect increases with the atomic weight; the insoluble salts of these metals are all innocuous. Soluble salts of Ca, Sr have marked toxic action. CaI_2, SrI are very poisonous.

Occurrence of zinc in the vegetable kingdom. L. LABAND. (Zeit. Nahrung Genussmitt, 1901, 4, 489-492.) The Author examined some plants grown in the neighbourhood of Scharley, Upper Silesia, on soil containing zinc and situated near zinc mines. He found 0·252 of ZnO in 100 grams of dry material.

Poisonous action of ferrocyanide of potassium on plants. S. SUZUCKI. (Bull. Coll. Agric. Tokyo, Imp. Univ., 1902, 5, 203-205.) Pot. Ferrocyn. in solution at 0·001 per thousand gradually destroyed barley plants.

Action of SO_2, ZnO, $ZnSO_4$ on soils and plants. EMIL HASELHOFF. (Jahresb. Landw. Versuch. Stat. Marburg, 1903-1904.) SO_2 does not injure soils; it is rapidly converted into H_2SO_4. ZnO (0·2 per cent.) has a slight effect on wheat. $ZnSO_4$ in the same proportion is found to be extremely injurious.

Can salts of Zn, Co, Ni, in high dilution, exert a stimulating action on agricultural plants? M. NAKAMURA. (Bull. Agric. Imp. Univ. Tokyo, 1904, 6, 147-152.) In experiments with *Allium* manured with $ZnSO_4$, $CoSO_4$, and $Co(NO_3)_2$, 0·01 gram in 2 to 3 kilos of soil, a slightly stimulating effect was observed in each case.

Pot culture experiments on MnI_2, MnO, K, Na, Li. JOHN A. VOELCKER. (Journ. Roy. Agric. Soc. England, 1904, 65, 306-314.) Mn, K, Na, and Li are injurious to wheat at the rate of 1 cwt. per acre.

Influence of Didymium and Glucinum on plants. G. KANOMATA. (Bull. Coll. Agric. Tokyo, 1908, 7, 637-640.) Barley was grown in pots containing 10 kilos of loamy soil, manured. Three pots received 0·01, 0·1, 0·5 grams of didymium nitrate. The plant grown with 0·018 showed an increase in total weight of 17 per cent., and in weight (42 per cent.), and number of ears. Larger doses had bad effect. A similar stimulating effect was observed when Didymium was applied to mustard, *Raphanus sativus radicula*, and tobacco, at the rate of 1 per million of soil. The increase in the last three experiments amounted to 13·7 per cent. with mustard, 27 per cent. with *Raphanus*, and 32·1 per cent. with tobacco. Glucinum nitrate, at the rate of 10 per million of soil had no appreciable effect, whilst larger amounts reduced the yield.

Barium in soils. G. H. FAILYER. (U.S. Dep. Agric. Bureau of Soils, Bull., 72, 1910.) Ba occurs in most soils of the U.S., more near Ba deposits. . . . Analysis of soils from Colorado and Kansas showed from 0·01 to 0·11 per cent. of Ba. Ba was also found in various plants from Nebraska, Colorado, and Kansas.

The action of Sr on algæ. OSCAR LOEW. (Flora, 1911, 102, 96-112.) Since algæ will live for some time in solutions of Sr salts, it may be supposed that Sr does not displace any of the essential metallic elements, Ca, Mg, &c., from their position in the protoplasm complex. Such injurious effect as is produced is mainly on the chlorophyll bodies, which lose their power of making starch, and their normal green colour, and finally die. $CaCl_2$ has no such action, even in 1 per cent. solution. . . . The Author considers that the nuclei and the chloroplast of the higher algæ are calcium compounds of nuclei proteins, because anything which precipitates Ca, potassium oxalates of NaF_2 has a strongly toxic effect.

Action of some hydrolysable salts, and of some colloids, on higher plants. ACHILLE GREGOIRE. (Bull. Soc. Chim. Belge, 1911, 25, 85-103.) The amount of silica absorbed by barley growing in presence of silica, analcime, and zeulandite, is large, amounting in case of SiO_2 to 44 per cent. of the total ash, whereas the control plant only contained 4·8 per cent. Analcime produced a larger crop than silicic acid, though the ash only contained 13 per cent. of SiO_2. So the 44 per cent. found in case of silica is apparently in excess of that required for the maximum development of the barley plant. It is considered that silica plays some essential part in the metabolism of barley. The relatively greater fertilising action of ammonium sulphate than sodium nitrate in the case of graminæ is attributed to the acid salt rendering more silicic acid available.

Presence of gold in marine plants. A. LIVERSIDGE. (J.C.S. Trans., XXV, pp. 298-299.) Gold is present in minute quantities in some marine plants.

Manuring with rare elements. STOCKLASA. (Blatt. Zuckerruberbau, 18, 153.) $MnSO_4$, $Al_2(SO_4)_3$ added to a basal fertiliser, increased the yield of sugar-beets from 30 to 50 per cent. $Pb(NO_3)_2$ in small quantities (1 per cent.) had a favourable effect, but with increased quantities the yield decreased. As_2O_3 or As_2O_5, up to 0·01 per cent., stimulates the growth; in larger proportion it is toxic.

Influence of Rubidium salts on growth of plants. OSCAR LOEW. (U.S. Dep. Agr. Bureau of Plant Industry, Bull., N. 45, 32.) Rubidium chloride exerts a powerful stimulating action on the growth of plants, when added in doses of 10 to 200 milligrames to 1 kilo of soil in which all mineral nutrients are present.

Catalytic fertilisers and the culture of sugar-beets. G. BERTRAND. (Engrais, 26, 852-3, 883-5.) In the ash of sugar-beets 0·04 per cent. consists of oxides of Fe, Mn, Al, B, Zn, Cs, and Rb, all in very small amounts. A catalytic agent is necessary for the fixation of O in the plants. This is the role of oxidases. On ashing the oxidase of the sugar-beet, an ash is obtained which is relatively rich in Mn. The absorption of O varies with the contents of Mn. Without the presence of Mn, laccase cannot function, and hence this metal is necessary for the complete functioning of the plant. The Mn to be available must exist in some soluble form, and must go into the soil solutions. The addition of soluble B and Zn salts also give good results with sugar-beets. The use of Mn and Zn together gave the most satisfactory results, and shows that the use of catalytic fertilisers exerts a tremendous influence on the growth of sugar-beet.

Influence of stannous chloride in fermentation. G. GIMEL. (Compt. Rend., 1908, 147, 1324-1236.) Kayser and others have found that Mn favours alcoholic fermentation. The Author finds that $SnCl_2$ has more marked effect; a culture containing 1 part in 10,000 producing 4 per cent. more alcohol than the culture of control.

Occurrence and role of Zinc in plants. MAURICE JAVILLIER. (Bull. Scient. Pharm., 1908, 15, 559-565.) Besides certain well-defined varieties growing on soils which are rich in zinc, most plants contain appreciable quantities of this metal, especially Conifers. Zinc can also act favourably on the growth of Phanerogams; for instance, cereals.

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